U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF SOILS

MILTON WHITNEY, CHIEF

Instructions to Field Parties

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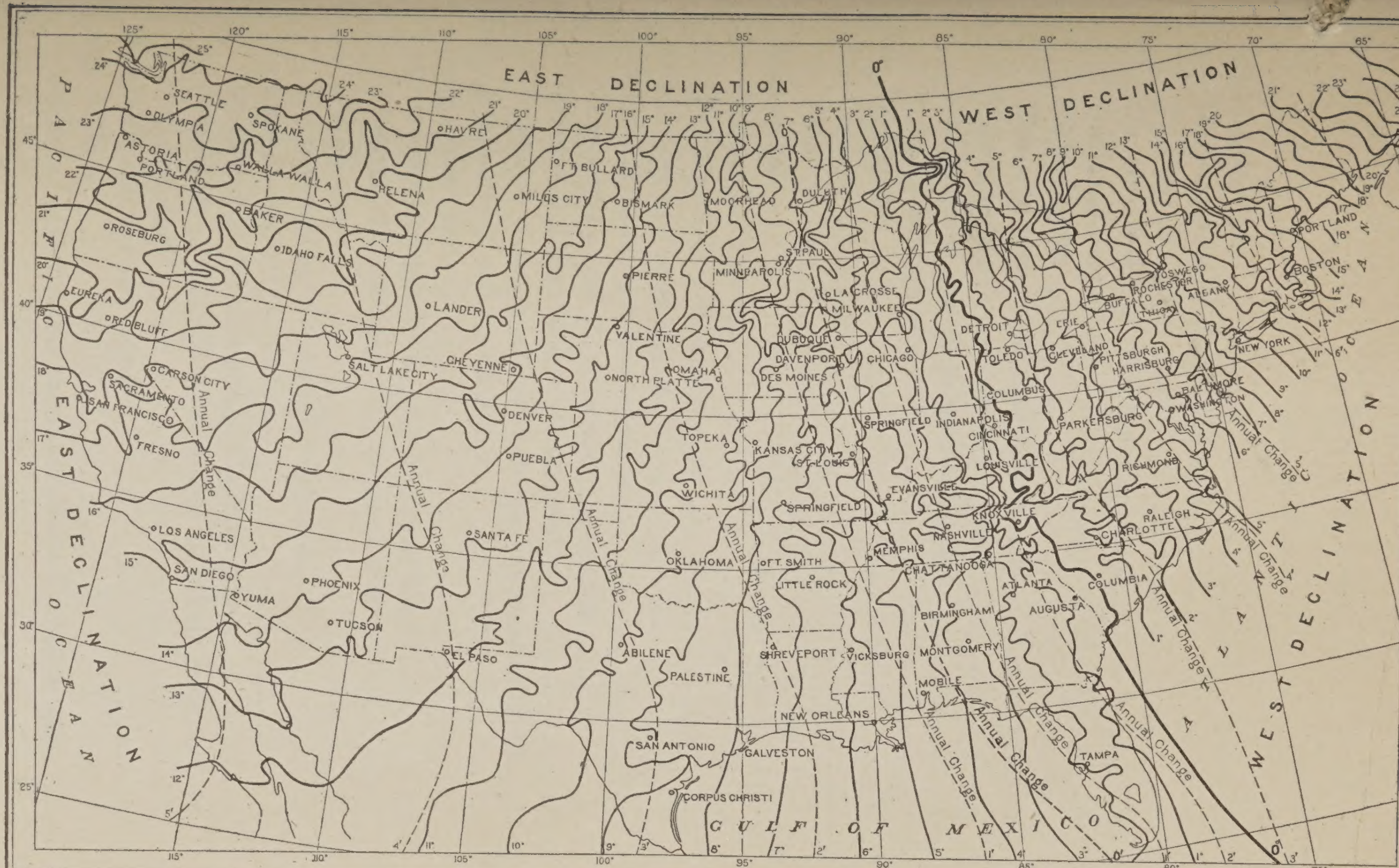

FIG. 1.—Lines of equal magnetic declination and equal annual change. (For explanation, see page 43.)

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ORGANIZATION OF THE SOIL SURVEY.

The Soil Survey is a division of the Bureau of Soils. The organization consists of a scientist in charge, inspectors in charge of inspection districts, State soil advisers, soil specialists, and a corps of field men, consisting of surveyors in charge of field parties and their assistants.

The corps of field men constitutes the main body of the Survey's staff. The work of these men is both fundamental and practical, and the whole organization exists for the purpose of unifying and making public the facts that they accumulate and the relationships which they point out.

The State soil advisers are Soil Survey officers assigned to the States for the purpose of interpreting the soil survey results to the men engaged in the various lines of agricultural investigation and demonstration in the State.

Soil specialists are Survey officers engaged in the study of special soil problems, such as the relation of soils to special crop distribution and the question of crop adaptation, so far as this is influenced by the character of the soil.

THE PURPOSE OF A SOIL SURVEY.

The purpose of a soil survey is to map, classify, and correlate soils, to determine and describe their field characteristics, to report on the actual use being made of the soils and on their adaptation to various crops, so far as can be determined, and upon the relative productiveness of the several soil types.

The field man should have a clear idea of the real value of the work he is doing and of its relation to the great industries of the country. In the gradual evolution of agricultural work the basic

nature of the work of the Soil Survey has come to be recognized. It is acknowledged that its primary function is to accumulate and make available knowledge concerning the soil, the soil's relation to crops, and the actual agricultural conditions obtaining on the soils of the country.

This knowledge is valuable to many classes of people, most of whom can be grouped under four heads:

1. Scientific men engaged in the investigation of problems relating to plant production, to farm management, to farm demonstration, to stock raising, to problems of rural organization, to road building, in short, to many of the branches of agricultural science.
2. The farmer.
3. Colonists, colonizing agencies, investors, development organizations, and individuals.
4. Students of geographic, social, and economic sciences, without reference to agricultural industries.

The Soil Survey is recognized as a scientific institution engaged in the accumulation of data bearing upon the soil and its relation to agriculture. The Soil Survey field man is a scientist and his results are important and his methods are scientific, as much so in his particular field as those of other scientists in their special lines of endeavor, whether working in the field, office, or laboratory. His methods are not the same as those of the laboratory man but his results are just as reliable when he has used his methods just as effectively. He is or should be not merely a getter of facts, but an interpreter of those facts. He must show relationships if he measures up to the opportunities afforded him. He has the opportunity to study soils and agricultural facts and relationships in a more intimate way than has ever been permitted to any one in this or any other country. No other scientific man has ever studied the actual soil and agricultural conditions of any country as closely and in as much detail as does the Soil Survey field man.

General Duties of Field Men.

Personal relation to State and department men.—It is expected that the Soil Survey staff will work in close relation with the department officers and cooperating State officials. The success of this

cooperative work will depend to a very great extent upon the field men, who will be in closer touch with the cooperating officers than anyone else in the bureau. This makes it imperative that the conduct of the field men should be such as to win the respect of these officers. Men associated with the bureau men in the field either representing the State or other bureaus of the Government should be treated with courtesy and consideration. The administrative officers in the States should be visited when convenient and an attitude of hearty cooperation should be shown in all our relations with them. For the maintenance of proper cooperative relations the Soil Survey men should familiarize themselves with the regulations of the cooperating organizations. Any misunderstanding of methods or criticism of the personnel of the cooperating forces where adjustment of such differences or misunderstandings can not be readily and amicably made by frank explanation should be taken up by correspondence with the chief of the bureau. The older men should exert every effort to train newly appointed assistants in the details of soil surveying with such care as will make them capable men, ready to take hold of the work with enthusiasm and conscientiousness. In no case should the new appointee be looked upon by the more experienced man as being valuable merely as a driver. The man in charge is expected to start such a recruit upon the actual performance of work the first time in the field, either in soil work or with the planetable. If the assistant proves capable he can soon be put to work alone, and thus made a valuable member of the party. On the other hand, should he not develop proper enthusiasm, energy, and capacity after persistent and conscientious instruction, the fact should be reported to the office and to the inspector.

Personal conduct of the field men.—In personal conduct, also, the bureau employee is expected to act in a way that will command the respect of the best element in the community where he happens to be at work. Public approval of the work and general acceptance of the results depend to a great extent on this, and the consideration of this fact should direct the personal conduct of the field man. He is the representative in the community of an important governmental organization and should earnestly endeavor to win respect by his personal conduct for the work in which he is engaged.

This will be secured not through any effort to push the claims of his work at all times or before all people, but rather by such attention to his daily work as will show the people with whom he comes in contact that he is a believer in the value of the work himself. Strict attention to the work wins respect for both the man and the work.

Relations to the public.—Courteous treatment of the public is required of every member of the force at all times. In answer to serious inquiries the purpose of the Soil Survey should be explained. It will not generally be necessary to go into such lengthy discussion as will interfere with the field work, since the essential features of soil surveying and the main purpose of the work can be briefly explained to those who are genuinely interested without loss of much time. Objections to entrance to the fields and lands on the part of owners, renters, and managers can usually be satisfactorily overcome by explanation of the work and its public nature, with the statement that no damage will be done to crops or property. It is best to secure permission from the proper authorities before entering upon lands to which the public generally is not admitted. In grazing regions where large areas are fenced permission should be secured for crossing the fences either by writing or interviewing the owners or managers. Staples pulled in letting down wire fences should invariably be carefully replaced, or the rails laid down in crossing rail fences should be replaced, and all gates closed.

Information to the press.—Usually a news item in regard to the survey of a county or area in the local papers will serve as an explanation of the work. In a newspaper statement of this kind it is necessary merely to give the names of the members of the party and to describe briefly the kind of map to be made and the value of such a map. Lengthy newspaper or magazine articles must have the approval of the chief of the bureau before being submitted for publication.

Information to cooperating officials.—During the progress of the work or at any other time the field man should furnish to any responsible cooperating official any information that may be asked concerning the progress of the survey work in the State or area with which the official is concerned, or any other information

relating to the work, it being understood that such information is for the official as an official and is not to be published or given out to the public in any other way. For other information reference should be made to the bureau.

Duties of Inspectors.

First inspection.—It is the duty of the inspector to visit each area surveyed in his division, usually twice, first to show the men in charge of an area what soil differences to map and to decide upon the textural and series name of the various soils. To accomplish this it is necessary for the inspector, in company with the man in charge of the party, to drive or walk over representative portions of the area and to make careful examinations of all the soils or at least all that can be seen on well-planned trips. Descriptions of the various soil types and phases should be recorded, from representative borings, in the field note book, by both the inspector and man in charge of the local area. At the completion of the inspection a report on form No. 65 should be submitted to the office.

Second inspection.—A second trip should be made to each area as near the completion of a survey as possible. On this trip the inspector should see all the soils and phases that have been mapped, taking such additional notes as may be necessary for the preparation of a comprehensive correlation memorandum. The character of mapping, the accuracy of traverse work, and of the delineation of soil boundaries should be carefully investigated, so that any necessary revision may be taken up with the field man upon the completion of the inspection. The field sheets should be examined to see that they join properly; that junction points of roads, streams, and soil boundaries can be understood by the draftsmen at the office; that each soil area, however small, is properly labeled with a symbol; that a complete legend is given on at least one of the field sheets; that such a legend corresponds in every detail with the symbols used on the map and that it includes every pencil number, letter symbol, or other symbol having any connection with the soils; that the name of the area and scale of the map are written on the back of each field sheet; that a line of magnetic north and south with the words "magnetic north" be placed on the front of

each sheet; and that a diagram showing by means of the sheet numbers the proper arrangement of the field sheets be drawn on the back of at least one sheet.

Preparation of correlation memorandum.—A final correlation memorandum should be prepared by the inspector before leaving the area. This should include such descriptions of each type and phase based upon field examination of the soils as will enable the suggested correlations and classifications to be checked by the correlation committee. In case the man in charge has not had much experience in writing soil survey reports, it is advisable to prepare the memorandum descriptions carefully, particularly the descriptions representing the typical development of the soils and their phases, so that such descriptions can be used by the field man in the preparation of his report. A copy of such a memorandum should be left with the man in charge, in case there is not sufficient time to have a typewritten copy returned from the office before the report is begun.

Reading manuscript reports.—On returning to the office the inspector is required to read the manuscript of the report on each area assigned to him for inspection before the report is submitted to the editor of the bureau, for the purpose of making such revision, corrections, or additions based upon his personal knowledge of the soils and conditions of the area as may in his judgment be required to insure accuracy in the presentation of the actual field conditions. After revising the manuscript a final correlation memorandum, including all added suggestions pertaining to the soils of each area, should be prepared for the committee on soil correlation. The galley proof of the report, which will be furnished the inspector as soon as published, should be carefully read by the inspector in order to correct possible errors.

Other duties.—The inspector should keep in touch with the reports of progress from the field parties in his division. In addition he will render such other services in connection with the work of the bureau as may be required. It is the duty of the inspector to call attention to any particularly meritorious work on the part of the field man which may justify consideration in questions of promotion. He should also report to the bureau any irregularities

connected with the work of the soil survey parties within his division that may come to his attention, whether connected with soil mapping, with the preparation of a report, or the personal conduct of the men.

Before leaving the area the inspector should fill out the following form and mail to this office:

Form of inspection report.

Form No. 65.

REPORT OF INSPECTION.

Area: .... State: ....

Estimated size of area .... square miles.

Work started ....

Surveyed to date .... square miles.

Average rate per week .... square miles.

Is the rate of progress satisfactory? ....

Is the progress delayed by—

(*a*) Long drives? ....

(*b*) Failure to recognize main soil distinctions instead of subordinate phases? ....

Have you given any instructions looking to a more rapid progress of the work, and what? ....

Is the party maintaining complete notes in field notebook, and are same up to date? (Instruct field men to send in field notebooks with reports and maps immediately upon completion of the area.) ....

Are the soil boundaries and traverse work on base map legible and uniformly indicated by proper symbols? ....

Do the symbols on base map correspond to the symbols and names in legend and in the report? ....

Are points of juncture of roads, streams, etc., so indicated on the traverse sheets at the edges that they can be properly understood and joined in the office? ....

What scale is being used on the map, and is it shown? ....

Are the proper cultural and hydrographic symbols being used, and is the magnetic north and south shown on the base map? ....

Is the area covered by the Land Office survey, and is each traverse circuit properly tied to land lines, corners, or other points of known location? ....

Is proper attention being given to the connecting of the work with previously surveyed adjoining areas? ....

Is a tracing or copy of the map being made, and are precautions being taken to insure the safety of the map? ....

Have you checked up the soil boundaries in the field in a sufficient number of cases to see that the field mapping is substantially correct? ....

Have descriptions of all soils been sent in to the office? ....

Are unnecessary samples being taken for analyses to determine texture? (Two samples should be sufficient for any type if carefully selected.)......

Has the preparation of the report been started? What progress has been made? ....

When do you think the area will be finished and the report completed and transmitted to the office? ....

Impress upon the field men that they should strive to have their maps and records legible and correct, with nothing obscure, so as to avoid all chance of error in office compilation and delay in preparation through the necessity of referring doubtful questions to the field. Make it clear also that the cost of the field work should be kept as low as is consistent with good progress and reasonable comfort.

A list of soils with suggested correlations accompanies this report.

Reached area...................... Left......................

Place.................... Signature............................
Inspector.

Area: .... State: ....

List of soils with suggested correlations. Those checked have been personally examined by me.

Field name.	Suggested correlation.
....	....
....	....
....	....

Soil correlation.—In the correlation and classification of soils the recommendations of the inspectors, who are familiar with the soils over wide regions and who will examine in the field all types and phases, will be given the most careful consideration in the final decision. Any change that may later appear to be advisable will be taken up with the party chief of the area in question, in order that he may submit a statement of his ideas in favor of or against such proposed changes, and these statements will be given full consideration before the final recommendations are submitted to the chief of the bureau for his approval or disapproval. Also any changes proposed which do not coincide with the inspector's recommendations will be taken up with the inspector, in order that he too shall have the opportunity to submit a statement of his ideas as to the advisability of such changes. In case of a series change proposed on the basis of soil samples submitted to the office, it will usually be the practice to send a small tube of the soil material of a questionable sample to the field man and to the inspector if he is

not in the office, so that errors rising from incorrect tagging or other sources will be eliminated if possible by a reinspection of the material.

Field Parties.

A field party in the detailed soil survey consists of two or more soil scientists, one of whom is assigned in charge. The assistant may or may not rank below the man in charge of a party. A certain amount of rotation is practiced in the assignment of men so that a man assigned to a field party as chief one year may be assigned as assistant another year. This shifting of responsibility tends to furnish opportunity to the younger men of the staff. While this is in general a policy of the office, no man is assigned as chief of a party until he has shown the ability to do the work and write the report.

The man in charge of any survey is responsible for the rate of progress and accuracy of the field work of the entire party, for the preparation of the report and maps, and for the carrying on of all necessary correspondence. The assistant performs such official duties as may be required of him by the man in charge. All members of a party should enter into the work with the will to help one another in every possible way, in order that the work may be carried forward at a good rate of progress and along lines leading to the construction of an accurate map and the writing of a good report. Each member of the party should keep in touch with the latest correlations presented in the publications of the bureau, such as Bulletin No. 96, and identify all soils occurring in the area. He should not, however, lose valuable time in attempting to correlate all the soils in his area when he finds such correlation difficult. A full and accurate description of a soil by the field man is much more important than is its field correlation.

In company with the inspector the man in charge should examine all the soils of the area and take such notes as the inspector takes. He should map those soils and phases pointed out by the inspector and also make any revision advised by the inspector. In case a type seen during the inspection is not subsequently found in important areas the field man should report that such a type was dropped on account of its small extent. The names approved by the inspector as the field names for the several soil types and phases

should be consistently used thereafter on all soil samples, in the legend of the field sheets and tracing, and in the report.

On rainy days the field men should work on their field sheets, the tracing copy required of the field sheets of all areas, prepare material for the report, and secure information regarding the agricultural practices of the area and other data needed in connection with the report.

Where the assistant is a new man he should in all cases work with the head of the party until he has become sufficiently efficient in traverse work and soil mapping to take up the work of mapping alone.

In carrying on the survey the work should be planned to avoid driving or walking over roads that have already been surveyed. Usually it is best not to carry the mapping more than 6 miles from headquarters, since work done at greater distances consumes much time in going and coming. This can be avoided by changing field headquarters and by stopping over one or more nights with farmers or at hotels situated close to the work. In working separately it is necessary to divide the area so that there will be no duplication of mapping. The man in charge, however, should from time to time look over the work of the assistant or assistants in order to maintain uniformity and to familiarize himself with the character of the work and the soils of the whole area.

Most of the mapping of detail areas is done by means of horse and buggy, an odometer attached to the wheel being used to measure distances. Where necessary boats and camping outfits should be secured to facilitate the work of the survey. In all cases a definite understanding as to charges should be reached with liverymen and the hirer of boats or other means of conveyance before final arrangements are made. It is advisable to inquire as to the peculiarities of horses, particularly to learn if there be any tendency toward colic, and to ascertain what to feed when stopping away from the barn. It is also a good plan to carry a supply of colic medicine, axle grease, a buggy wrench, wire, and necessary tools for making temporary repairs to vehicle or harness. It is usually possible to secure lower rates from liverymen where an outfit is to be used for a week or more. Such low rates should be secured by the man in charge whenever possible.

Plan and Organization of Field Work.

The field work of the survey is planned in such a way that most of the work during the summer season is carried on in the northern part of the country and in the winter season in the southern part. The size of the field party placed in an area is determined largely by the necessity arising from this arrangement of completing projects of survey work within a season so that there will be as little suspended work on account of seasonal transfer of parties as possible.

The number of men in each party, the individuals who shall compose it, and the man who will be placed in charge of the party are determined at headquarters, with the approval of the chief of the bureau. A letter of assignment is sent to each member of the party, the letter stating who will be in charge. Before the transfer can take place each member must have a letter of authorization, giving him authority to travel at Government expense.

When the party has reached the area to be surveyed the chief of the party assumes charge and proceeds to organize the work. His work includes the making of a soil map of the area, the study of the distribution of crops and types of agriculture, the study of the soils, their crop adaptations, and relative productiveness. His most important work is the making of the soil map. The soil mapping can be done only by placing on a base map certain lines showing soil boundaries and certain colors or conventional symbols (pencil numbers, letters, or both) to represent the existence, in the areas delineated, of certain soils.

Whenever possible a good base map will be furnished the chief of the field party upon his arrival in an area. This map should show streams, roads, railways, houses, churches, cities, and villages, township and section lines, and other permanently located objects, either natural or cultural. Where available, topographic maps will be furnished. Unfortunately, such a base map can not always be obtained. The area of country in the United States where this is possible is relatively small as yet and a considerable part of it covers mountainous regions, where detailed soil surveys are not frequently made.

Where no reliable base map exists the field man must construct one. In the former case his whole attention can be directed to the

soil mapping; in the latter case he must give attention to both base map making and soil mapping, either constructing the base map of an area and later doing his soil mapping or taking both up together and carrying them along at the same time.

The unit area of the soil survey is usually a county, some other unit being adopted in special cases and for special reasons only.

Correspondence and Weekly Report.

All correspondence with the bureau should be addressed to the chief of the bureau. At least once each week the head of the party should report to the chief by letter, informing him of the progress of the work and the results accomplished, describing the new types of soil, and giving a statement of the health of the members of the party. In addition, the weekly itinerary report (Form 140) must be filled out and returned to this office. The weekly itinerary reports must be on file covering every day upon which the employee is absent from headquarters in Washington, but are not to be considered as taking the place of the weekly letters.

Correspondence is filed in the office by areas and all correspondence should show the area number. Separate letters should, therefore, be written in regard to matters pertaining to different areas. Often letters are written that do not have a bearing upon any particular area, and such letters should also be written separately from letters relating to an area.

The bureau should be kept informed of the address of all the field men at all times, whether they are in the area to which they have been assigned, temporarily absent, or on leave of absence. Ordinarily this may be accomplished through the use of Form 140, but when absolutely necessary the telegraph may be used.

Soil Samples and Type Specifications.

Great care should be exercised in the collection of soil samples in order that they may truly represent the types. The samples at least of the well-established types should be collected during the progress of the field work rather than be postponed until the completion of the survey when, on account of the lack of time

or unfavorable weather conditions, it is frequently impossible to collect carefully selected, thoroughly representative samples.

The field names of types and phases agreed upon between the inspector and field man should subsequently be adhered to rigidly. Any suggestion by the field man as to correlation should be made in a memorandum accompanying the report. Caution should be exercised that the office be kept fully informed as to any subsequent changes in the soil name in those areas that have not been inspected, either through correlation with an established type or alteration in the series or class name. Confusion will be avoided if, in subsequent correspondence, either the old or original name be given in parenthesis after the new or substituted name, or only the original name be used until completion of the area, when a list showing all changes in names of soil types can be submitted with the report upon the area.

A soil to be correlated with a type must conform to it in certain broad, general features, but may differ from it in some details which do not greatly affect the crop value. The descriptions of the soil types given in Bulletin No. 96 must be taken as the definition of the general average of the type; and it must be remembered that certain minor variations or phases may occur in different areas.

In the selection of local names for new or doubtful types the series or apparent series relationship should be expressed—that is, soils which belong in the same series or are considered by the field man as belonging in the same series should be given the same series name. For example, soils found in a river bottom which differ only in texture should be classed in the same series. The same local or series name should not be employed for soils of different texture when no series relationship exists between them.

Samples for laboratory examination.—To avoid unnecessary work and to prevent overcrowding of the laboratory force, it will be necessary to use care and judgment in the selection of samples for mechanical or chemical examination.

At least one typical sample of soil and one of subsoil is to be sent to headquarters for every type recognized in the area except, possibly, stony or gravelly types that have no agricultural value and

classifications, such as meadow, which comprises a considerable range in texture and color of material.

The usual tag, Form 58, is to be attached to soil samples. This will give a brief description of the soil, which is needed to aid in identifying the sample and to check the field man's description of color. The area, collector, soil-type name, depth, and remarks, if necessary, are to be shown on this card, and care is to be used in giving, in distance and direction from the nearest town or by land lines, the exact location of the spot from which the sample was obtained. All writing on the tag (Form 58) should be in ink.

This sample is to represent the average and usual condition of the type in the area and should be in accord with the technical description given in the report. The sample is to be used at headquarters to check the color, and, when necessary, the texture by mechanical analysis. When samples are submitted varying to any extent from the typical conditions, the fact must be brought out clearly. If the sample represents a phase rather than the typical development of a type the phase name should be given on the tag, as, for example, Norfolk sandy loam, deep phase, Cecil clay loam, eroded phase.

Samples of soil submitted for special examination, such, for instance, as lime requirement determination, and specimens of rock for identification, should have the examinations desired carefully written in ink on the tag. It is well also to accompany such samples with a letter stating in detail what examinations are desired and the reasons therefor. Careful description records should be kept by the field men of such samples in order that laboratory results can be properly tied to the samples examined.

The plan of numbering soil samples serially heretofore in use has been done away with and a new system inaugurated, under which the field man is to number the samples in the field and his number is to be retained in the office, thus avoiding the confusion caused by having the field number different from the office number. In the present system each State has been given a number consisting of two figures; each area in the State will be given another number consisting of two figures. For instance, Indiana has been given the number "28;" Marshall County, as the fourth area surveyed, is "04." All samples from that area should bear the number "2804," thus indicating the State and area, to which are to be

added the numbers of the individual soil samples (whether a top soil, subsoil, or any portion of the subsoil which may be separately collected), beginning with "01" and continuing consecutively. Thus, if a survey party in Marshall County had collected 35 samples the last sample taken, whether of soil or subsoil, would be numbered "280435." Every soil sample number will thus contain six or more figures. No periods or commas are to be shown in the number. A list of the several States and the number assigned to each are given in the following table. When parties are sent to new areas the State and area number will be given in the letter of assignment, to which individual sample numbers are to be affixed. Each section of the soil collected should be given a different number serially—the soil should be numbered as one sample, the subsoil as another, and the deep subsoil, if a section of this is taken, as still another sample.

List of States and corresponding numbers to be used in numbering soil samples.

10. Maine.
11. New Hampshire.
12. Vermont.
13. Massachusetts.
14. Rhode Island.
15. Connecticut.
16. New York.
17. New Jersey.
18. Pennsylvania.
19. Delaware.
20. Maryland.
21. Virginia.
22. West Virginia.
23. North Carolina.
24. South Carolina.
25. Georgia.
26. Florida.
27. Ohio.
28. Indiana.
29. Illinois.
30. Michigan.
31. Wisconsin.
32. Minnesota.
33. Iowa.
34. Missouri.
35. North Dakota.
36. South Dakota.
37. Nebraska.
38. Kansas.
39. Kentucky.
40. Tennessee.
41. Alabama.
42. Mississippi.
43. Louisiana.
44. Texas.
45. Oklahoma.
46. Arkansas.
47. Montana.
48. Wyoming.
49. Colorado.
50. New Mexico.
51. Arizona.
52. Utah.
53. Nevada.
54. Idaho.
55. Washington.
56. Oregon.
57. California.
58. Porto Rico.

Soil specifications.—As soon as a field man has established the existence of a type of soil in the area in sufficient area to map, whether an old and well-known type or what is believed to be a new type, and after this is approved by the inspector, he is to write out the specifications on one of the following forms and send it to the office for the information of the official in charge of the soil survey and for the use of the correlation committee:

Form No. 66.

SPECIFICATIONS OF A SOIL OF THE PIEDMONT PLATEAU PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF .... (AREA).

.... (STATE).

Parent rock..

Color of soil..

Color of subsoil..

Texture of soil..

Texture of subsoil..

Structure of subsoil..

Substratum (if of modifying importance)..................................

Hardpan, if any..

Local modifications by wind and water (if of modifying importance)........

Drainage (if excessive or deficient)....................................

Topography..

Process of formation:

1. Residual..
2. Colluvial..

Field name..

Sample numbers..

Remarks..

Date .... Signature ....

Form No. 67.

SPECIFICATIONS OF A SOIL OF THE RIVER FLOOD PLAINS PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF .... (AREA).

.... (STATE).

Parent province material:

(*a*) Glacial..

(*b*) Piedmont..

Parent province material—Continued.
- (c) Appalachian..
- (d) Limestone..
- (e) Appalachian—Limestone..
- (f) Glacial—Appalachian..
- (g) Loessial..
- (h) Coastal Plain..
- (i) Coastal Plain—Piedmont—Appalachian..
- (j) Residual Prairie..

Parent rock or soil material..
Drainage (well or poorly established)..
First or second bottom..
Color of soil..
Color of subsoil..
Texture of soil..
Texture of subsoil..
Structure of subsoil..
Hardpan, if any..
Substratum (if of modifying importance)..
Modification by salt water, if any..
Calcareous nature, if marked..
Field name..
Sample numbers..
Remarks..
Date ....   Signature ....

Form No. 68.

SPECIFICATIONS OF A SOIL OF THE LIMESTONE VALLEYS AND UPLANDS PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF .... (AREA).

.... (STATE).

Color of soil..
Color of subsoil..
Texture of soil..
Texture of subsoil..
Structure of subsoil..
Substratum (if of modifying importance)..
Parent rock..

Hardpan, if any..

Drainage (if excessive or deficient)..

Topography..

Process of formation:

1. Residual...

2. Colluvial..

Field name..

Sample numbers..

Remarks...

Date ....   Signature ....

Form No. 69.

SPECIFICATIONS OF A SOIL OF THE GLACIAL AND LOESSIAL PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF .... (AREA).

.... (STATE).

Soil derived from—

(*a*) Thick glacial till...

(*b*) Thick glacial till assorted or modified by glacial waters and wind:

1. Morainic ....

2. Outwash plains and filled in valleys.......................................

(*c*) Thin glacial till...

(*d*) Thin glacial till assorted or modified by rushing glacial waters and wind:

1. Morainic...

2. Outwash plains and filled in valleys.......................................

(*e*) Loessial deposits...

Parent material what principal rocks..

Color of soil...

Color of subsoil..

Texture of soil...

Texture of subsoil..

Structure of subsoil..

Hardpan, if any...

Substratum (if of modifying importance).......................................

Drainage..

Topography..

Field name..

Sample numbers..

Remarks...

Date ....   Signature ....

Form No. 70.

SPECIFICATIONS OF A SOIL OF THE GLACIAL LAKE AND RIVER TERRACE PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF .... (AREA).

.... (STATE).

Drainage (well or poorly established)..

Color of soil..

Color of subsoil...

Texture of soil..

Texture of subsoil...

Structure of subsoil...

Hardpan, if any..

Parent material..

Substratum (if of modifying importance)................................

Surface configuration (terrace, lake beds, hillocks, or ridges)...............

Field name...

Sample numbers...

Remarks..

Date .... Signature ....

Form No. 71.

SPECIFICATIONS OF A SOIL OF THE APPALACHIAN PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF .... (AREA).

.... (STATE).

Color of soil..

Color of subsoil...

Texture of soil..

Texture of subsoil...

Structure of subsoil...

Substratum (if of modifying importance)................................

Parent material..

Hardpan, if any..

Drainage...

Topography...

Process of formation:

1. Residual..
2. Colluvial...

Field name..

Sample number.. ....

Remarks..

Date .... Signature ....

Form No. 72.

SPECIFICATIONS OF A SOIL OF THE COASTAL PLAIN PROVINCE.

ENCOUNTERED IN THE SOIL SURVEY OF......................(AREA)

......................(STATE).

Parent province material:
- (*a*) Glacial—Piedmont—Appalachian..
- (*b*) Piedmont—Appalachian..
- (*c*) Loessial...
- (*d*) Calcareous...
- (*e*) Residual Prairie...
- (*f*) Coastal Plain—Reworked or Mixed..

Color of soil...

Color of subsoil..

Texture of soil...

Texture of subsoil..

Structure of subsoil..

Substratum (if of modifying importance)...

Calcareous nature, if marked..

Iron concretions, if any ....

Hardpan, if any...

Drainage..

Hummocky surface, if any..

Prairie, if any...

Topography..

Field name..

Sample numbers..

Remarks...

Date...................... Signature...............................

Form No. 78.

Specifications of a soil of the—

NORTHWEST INTERMOUNTAIN REGION.
GREAT BASIN REGION.
ARID SOUTHWEST REGION.
ROCKY MOUNTAIN REGION.
GREAT PLAINS REGION.

ENCOUNTERED IN THE SOIL SURVEY OF THE..................(AREA).

......................(STATE).

Soil type..

Province:

Residual—

Character of rock..

Glacial—

1. Agencies—

(*a*) Ice-laid..

(*b*) Water-laid..

2. Parent material..

Lake-laid—

Parent material..

Wind-laid—

1. Loessial, recent..

2. Parent material..

Outwash Plain (includes colluvial and alluvial footslope, alluvial fan and filled valley plains material).................................

Coastal Plain—

Parent material..

River Flood Plains—

Parent material..

NOTE.—In indicating source of parent material state—

1. Character of parent rock if known. If from sedimentary rocks, state whether cherty or chert-free limestone, sandstone, shale, or alternating beds of above formations........

2. Age and name of geologic formation if determined............

3. Character of soil, or series name if derived from adjacent soil material..

Modified by:

Erosion; æolian, alluvial, colluvial, or lacustrine agencies; weathering, drainage, leaching; accumulation of organic deposits, chemical precipitates, etc.; or by other agencies and conditions....................

Regional topography:

Mountain and hillslope or footslope, plateau or mesa surface, upland plain; morainic—ground moraine, lateral moraine, terminal moraine, etc.; kame, esker, outwash plain, glacial terrace, etc.; lake basin floor; beaches, deltas, spits, bars, embankments, cut and built terraces, etc., of lake basin and coastal plains; land slip terrace, fault terrace; débris aprons, slopes and floors of filled valleys, alluvial fans; alluvial valley slopes, flood plains and terraces; etc....................................

If terrace or mesa state approximate elevation above adjacent soil material..

Soil:

Color..

Texture..

Depth..

Structure..

Organic-matter content..

Subsoil:

Color..

Texture..

Depth..

Structure..

(If more than one subsoil or substratum occurs, describe each.)

Other underlying material:

1. Substratum—depth to, and character of material.....................

2. Hardpan—character, thickness, and position of material, if present..

Gravel and bowlders:

1. Amount, size, and character..

2. Occurring in soil, subsoil, or both..

Rock outcrop:
Character and amount..

Occurrence of conspicuous concretions, volcanic dust, pumice or other fragmental ejecta, iron crusts, nodules, calcareous material; mica, quartz, or feldspar particles or other recognized minerals, in soil and subsoil.........

Surface configuration:
1. Level, sloping, undulating, rolling, hilly, dissected, precipitous, smooth, irregular, hummocky, eroded, etc..........................
2. Relation to erosion, and adaptability to irrigation....................
3. Drainage—relation to overflow, surface, and subdrainage.............

Occurrence of alkali..

Native vegetation..

Present utilization..

Crop yields—heavy, light, or medium................................

Special adaptation to crops..

Remarks:
1. Note any essential or modifying features not already mentioned......
2. Suggestions as regards correlation..............................

Laboratory sample Nos..

Date.................... Signature..........................

Form No. 79.

SPECIFICATIONS OF A SOIL OF THE PACIFIC COAST REGION.

ENCOUNTERED IN THE SOIL SURVEY OF THE................(AREA).
....................(STATE).

Soil type..

Province:
Residual—
Character of rock..
Glacial—
1. Agencies—
a. Ice-laid..
b. Water-laid..
2. Parent material..
Lake-laid—
Parent material..
Wind-laid—
Parent material..
Coastal Plain and older valley filling—
Parent material..
Alluvial fan and recent valley filling. (Includes colluvial and alluvial footslope, alluvial fan, and filled valley plains material)—
Parent material..
River Flood Plains—
Parent material..
NOTE.—In indicating source of parent material, state:
1. Character of parent rock, if known. If from sedimentary rocks state whether cherty or chert-free limestone, sandstone, shale, or alternating beds of above formations........................
2. Age and name of geologic formation if determined................
3. Character of soil, or series name if derived from adjacent soil material..

Modified by:
Erosion; æolian, alluvial, colluvial, or lacustrine agencies; weathering, drainage, leaching; accumulation of organic deposits, chemical precipitates, etc.; or by other agencies and conditions....................

Regional topography:
Mountain and hillslope or footslope, plateau or mesa surface, upland plain; morainic—ground moraine, lateral moraine, terminal moraine, etc.; kame, esker, outwash plain, glacial terrace, etc.; lake basin floor; beaches, deltas, spits, bars, embankments, cut and built terraces, etc., of lake basin and coastal plains; land slip terrace, fault terrace; débris aprons, slopes and floors of filled valleys, alluvial fans; alluvial valley slopes, flood plains, and terraces, etc..............................
If terrace or mesa state approximate elevation above adjacent soil material..

Soil:
Color..
Texture..
Depth..
Structure..
Organic-matter content.................................

Subsoil:
Color..
Texture..
Depth..
Structure..
(If more than one subsoil or substratum occurs, describe each.)

Other underlying material:
1. Substratum, depth to, and character of material....................
2. Hardpan; character, thickness, and position of material, if present...

Gravel and bowlders:
1. Amount, size, and character..................................
2. Occurring in soil, subsoil, or both..............................

Rock outcrop:
Character and amount...

Occurrence of conspicuous concretions, volcanic dust, pumice or other fragmental ejecta, iron crusts, nodules, calcareous material, mica, quartz, or feldspar particles or other recognized minerals, in soil and subsoil.........

Surface configuration:
1. Level, sloping, undulating, rolling, hilly, dissected, precipitous, smooth, irregular, hummocky, eroded, etc.........................
2. Relation to erosion and adaptability to irrigation....................
3. Drainage—relation to overflow, surface, and subdrainage............

Occurrence of alkali..

Native vegetation...

Present utilization..

Crop yields—heavy, light, or medium.............................

Special adaptation to crops.......................................

Remarks:
1. Note any essential or modifying features not already mentioned......
2. Suggestions as regards correlation..............................

Laboratory sample Nos...

Signature..........................

Date...................

Care of Instruments.

Too much emphasis can not be laid upon the importance of care in handling and transporting instruments. Every employee intrusted with instruments in the field will be expected to protect them from undue wear and to return them to the custodian in fit order for use.

Accounts.

Reimbursement accounts should be submitted promptly at the close of each month, and must be rendered in strict accordance with the provisions of the Department Fiscal Regulations. A copy of these regulations should be in the hands of every field employee, and may be obtained through the office of the chief clerk of the bureau.

Leave of Absence.

A copy of the regulations is furnished all employees, and a strict observance of these regulations is enjoined upon every employee.

Field Outfit.

The outfit for field work consists of the following for each member of the party:

Soil auger, 40-inch.
Geologist's hammer.
Notebooks.
Field diary.
Set of colored pencils.
Base map.
Bottle of blue litmus paper.
Bottle of red litmus paper.
Small bottle of hydrochloric acid.
Sacks and tags (Form 58) for collecting samples of soil.
Soft pencils.
Requisition Form No. 60.
Subvouchers for livery hire, meals, and lodging, Form 4 A.
Expense account sheets, Form No. 4.
Mail forwarding cards, Form 62.
Form 63, for transferring property.
Official telegram blanks, Form E 1.
Supply of stationery.

Copy Instructions to field men.
Copy of Bulletin No. 96.
Copy of Topographic instructions of the United States Geological Survey.
Copy latest edition Fiscal regulations.
Address cards, Form 50.

When doing traverse work each member of party should have a complete planetable outfit, including:

Planetable.
Odometer.
Alidade, with chain scale attachment.
Alidade case.
Paper of small needles.
Supply of No. 4–H, 6–H, and 9–H pencils.
Pencil erasers.
Ink erasers.
Leather case for holding planetable top and maps.
Fine-textured sandpaper for sharpening hard pencils.
Supply of cover paper for protecting field sheets.
Supply of thumb tacks.

The man in charge should have a supply of:

Planetable paper.
Tracing cloth.
Triangles.
Straight edge.
Ruling pens.
Crow-quill pens.
Waterproof ink—red, blue, and black.
Weekly itinerary sheets, Form 140.
Pliers.
Specification sheets for provinces represented in the area, as follows:
Form No. 66, Piedmont Plateau Province.
67, River Flood Plains Province.
68, Limestone Valleys and Uplands Province.
69, Glacial and Loessial Province.
70, Glacial Lake and River Terrace Province.
71, Appalachian Mountains and Plateau Province.
72, Coastal Plain Province.
78, Northwestern Intermountain Region.
Great Basin Region.
Arid Southwest.
Rocky Mountain Region.
Great Plains Region.
79, Pacific Coast Region.

In addition to the above, parties equipped for making alkali surveys should add the alkali outfit:

Electrolytic bridge.
Cell.
Mixing cups.
Spatula.
Thermometers.
Burettes.
Measuring receptacles.
Extension augers.
Pipe wrenches.
Filter pump.
Screw driver.
Metallic tape 50 feet long.
Mailing cases.
Water bottles.

Additional supplies required for special purposes, such as sketching cases, tally registers, field glasses, and canteens, may be obtained upon the regular requisition Form No. 60 as needed. In sparsely settled areas a complete camp equipment will be provided.

The loss of or damage to any supplies should at once be reported to the office, with explanation of the cause of such loss or damage. (See Form No. 25 below.)

UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF SOILS.

CERTIFICATE OF PROPERTY LOST OR BEYOND REPAIR.

(P. O.) ....

................................, 191 .

I hereby certify that the following articles.................................
for which .... is accountable have been
....
("Lost," "broken beyond repair," or "worn out," as the case may be.)
in the following manner: ....

(Signature) ....

(Title) ....

Approved:

....

In Charge.

.... is hereby .... responsibility for the ....
.... of the above-enumerated Government property, the value of which is $................, and the property clerk is authorized to drop said property from his returns.

....

Chief Clerk of Bureau.

Immediately upon learning of a new assignment the man to have charge should communicate with the office to ascertain what supplies will be needed in the new area, advising the office as to supplies on hand which may be used in the new area. Whenever possible arrangements should be made by correspondence with the office for shipment of the necessary supplies in time to reach the area so as to avoid delay in the field work.

BASE MAPS.

A detailed soil map is usually published on a scale of 1 inch to the mile; reconnoissance soil maps on a scale of 4 or 6 miles to the inch. The actual field mapping in a detailed area may be done on a scale of 1 inch to the mile or 2 inches to the mile according to the judgment of the field man, the scale of mapping depending on the complexity of the soils in the area. This is usually possible to determine in the preliminary examination in company with the inspector.

The base maps furnished by the office consist, where available, of sheets of the topographic atlas of the United States published by the United States Geological Survey. When these are published on the scale of $\frac{1}{62500}$ (about 1 inch to the mile) or on a larger scale, they can usually be used directly as the base map for the soil mapping. When published on the smaller scale they may be enlarged by photography for use as a base map for detailed soil mapping or they may be used merely as a guide in getting over the area according as the correctness and adequacy of details permit.

The method of construction of topographic sheets, including the units, the projection, the methods of showing Land Office corners, boundary monuments, triangulation stations, etc., and the symbols used to express topographic and other physical features, including cultural features and hydrographic features are given in "Topographic Instructions of the United States Geological Survey," which should be consulted as a matter of information by all field men.

When topographic sheets are not available, Land Office township plats of the area, if these can be obtained, will be furnished. These are on a scale of approximately 2 inches to the mile and may be

used directly for the mapping of soils or as guides for the preparation of the base map.

Where county maps based upon Land Office plats are furnished as a base, the size and shape of the sections should be most carefully checked with the odometer and planetable. In all cases, no official Government map or any county map published for commercial purposes which is more than a few years old should be used as a base map without careful scrutiny to discover possible errors.

Making a Base Map.

The making of a base map consists essentially of plotting on paper the distances and direction of physical features and the use of names and symbols in indicating the character of these different features in such a way as to convey an intelligent and correct impression of the character of the country. To measure distances, the Bureau of Soils generally uses the odometer for a so-called wheel traverse. Where the wheel traverse can not be made on account of the character of the country, a foot traverse or simple triangulation is resorted to. To determine directions, a simple form of planetable or sometimes a compass or an army sketching case is used.

Measuring distances.—In the ordinary detailed surveys road distances are measured by the revolutions of a buggy wheel, the circumference of which has been carefully determined to the nearest tenth of a foot by a steel tape. The number of revolutions made by the wheel between two given points is usually recorded on an odometer or revolution counter. Given the circumference of the wheel and the number of revolutions of the wheel between two given points, the distance in feet can easily be calculated. Obviously 100 revolutions of a wheel 9.2 feet in circumference differ materially from 100 revolutions of a wheel which is 11.2 feet in circumference. For plotting measured distances upon a map, a boxwood rule called a chain scale is used with divisions equaling one-fiftieth of an inch, which on a scale of 1 mile to the inch would be equivalent to one-fiftieth of a mile. For convenience in plotting distances, the number of revolutions equaling one-fiftieth of a mile for wheels of different circumferences have been

computed and are given in a table, so that for a wheel of a given size a certain number of revolutions are found to be equivalent to so many scale divisions and the distance is therefore plotted on the paper by use of the chain scale from the number of revolutions as fiftieths of a mile.

The odometer.—The odometer (see fig. 2) in general use is the Bell revolution counter. The red hand registers each revolution of the buggy wheel from 0 to 100; the yellow hand registers each 100 revolutions up to 4,000, and the blue hand registers each 4,000 revolutions up to 40,000. With each revolution of the wheel, the red hand moves one space on the outer circle of the dial, completing the circuit in 100 revolutions of the wheel. When the red hand has gone around once and back to zero the yellow hand moves one space on the inner circle, and when the yellow hand has completed the circuit the blue hand moves one space forward on the inner circle. In reading the yellow hand it is necessary to be very careful, since the yellow hand begins to move after the red hand passes 90 and may reach the next space division on the inner circle before the red hand reaches zero. Reading the yellow hand one space forward before the red hand

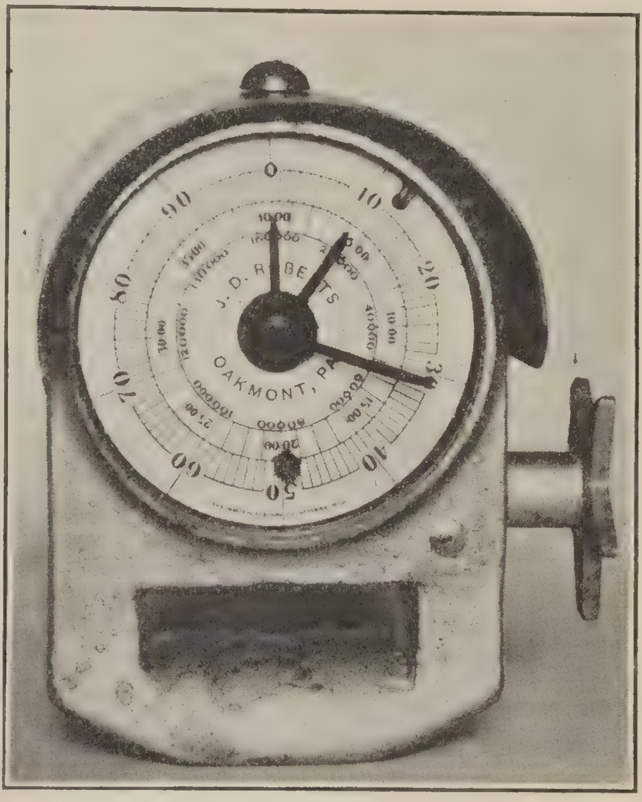

FIG. 2.—Odometer. (Patented.)

had reached zero would mean an error of 100 revolutions too great. Care must be taken, therefore, at this place in reading the revolutions of the red hand to see that the correct hundreds as indicated by the yellow hand is taken.

The odometer should be clamped to the front axle close to the right wheel, face backward. It can be fastened on the axle with an iron clip or with a strong leather strap and a wooden wedge to tighten the strap. The spur wheel of the odometer should be placed within one-third to one-half inch of the hub and so arranged that it will revolve in essentially the same plane as the buggy wheel. The spur is turned through a part of a revolution with each revolution of the buggy wheel by means of a trip pin, consisting of a headless wire nail or round spike driven into the end of the hub, or better still, by a pin fastened in an iron band which fits around the hub and can be attached or taken off very easily. The trip pin should be bent to whatever angle is necessary to make it pass freely under the spur wheel of the odometer, striking the cogs about one-eighth inch from their ends. The buggy wheel should have a minimum of play on the axle, or else the trip pin may not operate the spur wheel properly. An odometer not in good working order should not be used.

In case the traverse man has no odometer he can count the revolutions of the wheel as a temporary expedient. To do this he should tie some conspicuous object, such as a piece of white cloth or a small bush, to a spoke of the wheel. Counting the revolutions holds the attention too close for the performance of the best work, especially in the mapping of soils, and should not be substituted for the odometer except when absolutely necessary.

The chain scale.—Having determined the number of revolutions of a wheel of known circumference between two points, it remains to plot this distance on the paper in the easiest way. This is done by the use of a chain scale, the construction of which is as follows:

The chain scale used in the field work consists of a small light boxwood ruler (see fig. 3) about 7½ inches long with beveled edges faced with celluloid, upon which a United States standard scale has been cut. Upon one side marked "50" the scale is in black and 50 divisions represent 1 inch, or 1 mile if the scale of the map is 1

mile to the inch. Each division on this side of the scale represents one-fiftieth of an inch or one-fiftieth of a mile on an inch to the mile scale.

The other side of the chain scale has the number 5,280 and the scale divisions are in red. On this scale there are 52.8 divisions to the inch, or 52.8 divisions will represent a mile on the scale of an inch to the mile. As there are 5,280 feet to the mile, one division on this scale will equal 100 feet on an inch to the mile scale. This side of

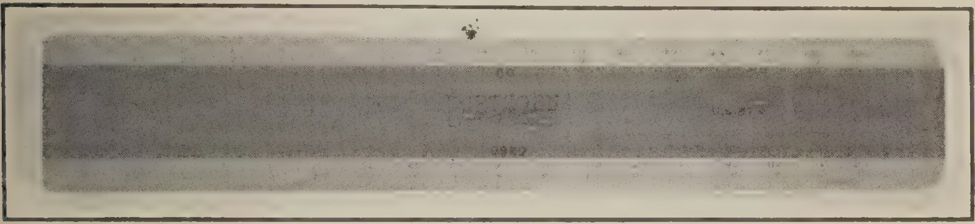

FIG. 3.—Chain scale.

the scale marked in red figures coming under the number 5,280 must never be used in connection with the traverse unless the distances are calculated in feet, but must always be used in the traverse where the distances are measured in feet.

The following table is arranged for the ready conversion of number of revolutions of the different size buggy wheels directly to the chain scale divisions of fiftieths of an inch or fiftieths of a mile (1 inch=1 mile scale), thus obviating the necessity of reducing the number or revolutions to the number of feet traversed:

Scale division.	Circumference of wheel in feet.													
$\frac{1}{80}$ mile	9.5	9.6	9.7	9.8	9.9	10	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8
	Number of revolutions of wheel.													
1	11	11	11	11	11	11	10	10	10	10	10	10	10	10
2	22	22	22	22	21	21	21	21	20	20	20	20	20	20
3	33	33	33	32	32	32	31	31	31	30	30	30	30	29
4	44	44	44	43	43	42	41	41	41	41	40	40	40	39
5	56	55	54	54	53	53	52	52	51	51	50	50	49	49
6	67	66	65	65	64	63	63	62	62	61	60	60	59	59
7	78	77	76	75	75	75	73	73	72	71	70	70	69	68
8	89	88	87	86	85	85	84	83	82	81	80	80	79	78
9	100	99	98	97	96	96	94	93	92	91	90	90	89	88
10	111	110	109	108	107	106	105	104	103	102	101	100	99	98
11	122	121	120	119	117	116	115	114	113	112	111	110	109	108
12	133	132	131	129	128	127	126	124	123	122	121	120	119	118
13	144	143	142	140	138	137	136	135	133	132	131	130	128	127
14	155	154	152	151	149	148	147	145	144	142	141	140	138	137
15	167	165	163	162	160	158	157	155	154	152	151	149	148	147
16	178	177	174	172	170	169	167	166	164	163	161	159	158	156
17	189	188	185	183	181	180	178	176	174	173	171	169	168	166
18	200	199	196	194	192	190	188	186	185	183	181	179	178	176
19	211	209	206	205	203	201	199	197	195	193	191	189	188	186
20	222	220	218	216	213	211	209	207	204	203	201	199	198	196
21	233	231	228	226	224	222	220	218	214	213	211	209	207	205
22	244	242	239	237	235	232	231	229	224	223	221	219	217	215
23	255	253	250	248	245	243	241	239	235	233	231	229	227	225
24	266	264	261	259	256	253	252	249	245	244	241	239	237	235
25	278	275	272	270	267	264	262	259	256	254	251	249	247	244
26	289	286	283	280	277	275	272	269	267	264	262	259	257	254
27	300	297	294	291	288	285	282	280	277	274	272	269	267	264
28	311	308	305	302	298	296	293	290	287	284	282	279	277	274
29	322	319	316	313	309	306	303	300	297	295	292	289	287	283
30	333	330	326	324	320	317	314	311	308	305	302	299	296	293
31	344	341	337	334	330	327	324	321	318	315	312	309	306	303
32	355	352	348	345	341	338	334	332	328	325	322	319	316	313
33	366	363	359	356	352	349	345	342	338	335	332	329	326	323
34	378	374	370	366	362	359	355	352	349	345	342	339	336	332
35	389	385	381	377	373	370	366	363	359	356	352	349	346	341
36	400	396	392	388	384	380	376	373	369	366	362	359	356	351
37	411	407	403	400	394	391	386	383	380	376	372	369	366	361
38	422	418	414	410	405	401	397	394	390	386	382	379	375	371
39	433	429	424	421	416	412	408	404	400	396	392	389	385	381
40	444	440	435	431	426	422	418	414	410	406	402	398	395	391
41	455	451	446	442	437	433	429	425	421	416	412	408	405	401
42	466	462	457	453	448	444	439	435	431	426	422	418	415	411
43	478	473	468	464	458	454	450	446	441	437	433	428	425	421
44	489	484	479	474	469	465	460	456	451	447	443	438	435	430
45	500	495	490	485	480	475	471	466	462	457	453	448	445	440
46	511	506	500	496	490	486	481	476	472	467	463	458	454	450
47	522	517	511	506	501	496	492	487	482	478	473	468	464	460
48	533	528	522	517	512	507	502	497	492	488	483	478	474	469
49	544	539	533	528	522	517	513	508	503	498	493	488	484	479
50	555	550	544	539	533	528	523	518	513	508	503	498	494	489

Scale division.	Circumference of wheel in feet.													
$\frac{1}{50}$ mile	10.9	11	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12	12.1	12.2
	Number of revolutions of wheel.													
1	10	10	10	9	9	9	9	9	9	9	9	9	9	9
2	19	19	19	19	19	18	18	18	18	18	18	18	17	17
3	29	29	29	28	28	28	28	27	27	27	27	26	26	26
4	39	38	38	38	37	37	37	36	36	36	35	35	35	35
5	48	48	48	47	47	46	46	46	45	45	44	44	44	43
6	58	57	57	57	56	56	55	55	54	53	53	53	53	52
7	68	67	66	66	65	65	63	64	63	62	62	62	61	61
8	78	76	76	76	74	74	72	73	72	72	71	70	70	69
9	87	86	85	84	83	83	82	82	81	80	80	79	79	78
10	97	96	95	94	93	93	92	91	90	89	89	88	87	87
11	107	106	104	104	103	102	101	100	99	98	98	96	96	95
12	116	115	114	113	112	111	110	109	108	107	107	104	105	104
13	126	124	124	122	122	120	119	118	117	116	115	113	113	113
14	136	134	133	132	131	129	128	127	126	125	124	122	122	121
15	145	144	143	141	140	139	138	136	135	134	133	132	131	130
16	155	154	152	151	150	148	147	146	144	143	142	141	139	138
17	165	163	161	160	159	157	156	155	153	152	151	150	148	147
18	175	173	171	169	168	167	165	164	162	161	160	158	157	156
19	184	182	180	179	178	176	174	173	171	170	169	168	165	165
20	193	192	190	188	187	185	184	182	180	179	178	176	174	173
21	202	202	200	198	196	195	193	191	189	187	187	185	183	182
22	212	211	209	207	205	204	202	200	198	197	195	194	192	191
23	222	221	219	217	215	213	211	209	207	206	204	202	201	199
24	232	230	229	226	224	222	220	218	217	215	213	211	209	208
25	242	240	238	236	234	231	229	227	225	223	222	220	218	216
26	252	250	248	245	243	241	239	237	235	232	231	229	227	225
27	261	259	257	255	253	250	248	246	244	241	240	238	235	234
28	271	268	267	264	261	259	257	255	253	250	249	246	244	243
29	281	278	276	274	271	269	266	264	262	259	258	255	253	251
30	290	288	286	283	280	278	275	273	271	268	266	264	262	260
31	300	298	295	292	290	287	285	282	280	277	275	273	270	268
32	310	307	305	302	299	296	294	291	289	286	284	281	279	277
33	319	317	314	312	308	306	303	300	298	295	293	290	288	286
34	329	326	324	321	318	315	312	309	307	304	302	299	296	294
35	339	336	333	330	327	324	321	318	316	313	311	308	305	303
36	349	346	343	339	336	333	331	328	325	321	320	317	314	312
37	358	355	352	348	346	343	340	337	334	330	329	326	323	320
38	368	365	362	358	355	352	349	346	343	339	338	334	331	329
39	378	374	371	367	364	361	358	355	352	348	346	343	340	338
40	387	384	381	377	374	370	367	364	361	358	355	352	349	346
41	397	394	390	386	383	380	377	373	370	367	364	361	358	356
42	407	403	400	396	392	389	386	382	379	376	373	370	366	364
43	416	413	409	405	402	398	395	391	388	385	382	378	375	372
44	426	422	419	415	411	407	404	400	397	393	391	388	384	381
45	436	432	428	424	420	417	413	410	406	402	399	396	392	390
46	445	442	438	434	430	426	422	419	415	411	409	405	401	399
47	455	451	447	443	439	435	432	428	424	420	417	414	410	408
48	465	461	457	452	448	445	441	437	433	429	426	422	419	417
49	474	470	466	461	458	454	450	446	442	438	435	431	427	425
50	484	480	476	471	467	463	459	455	451	447	444	440	436	433

Foot traverse.—In wooded areas, cultivated fields, and generally along streams, in order to obtain distances between soil boundaries and physical features it is necessary to resort to foot traverse in which the distances are measured by the number of steps taken by a man or a horse. In establishing the relation between the steps taken and the distance covered it is necessary to measure with a steel tape or between land office stations or other known distances of a quarter or a half mile, the number of steps taken by the man or a horse at their ordinary gait. Having thus established the average length of a single pace, the number of paces between objects can readily be converted into feet and the distance so determined between these objects plotted on the map, using the red figures on the chain scale and allowing 100 feet to each division of the scale.

Triangulation.—The method of plotting distances which are inaccessible to a buggy and where the foot traverse can not readily be used, will be indicated under the description of the planetable and its use.

Traverse notes.—In recording measurements of distance, whether determined with the odometer, in foot traverse, or by other means, the measurement figures of reading points—of set-up stations, turning stations, soil boundaries, streams, branch roads, houses, etc.—should be carefully set down in the notebook by the man running the planetable. In recording measurements of the odometer the readings as indicated by the yellow hand and red hand should always be taken and set down, so that they can be referred to at any time and used as a check on the distances indicated on the map. A convenient method of recording such readings is to set them down along a line beginning at the bottom of the notebook page and proceeding upward as the work progresses. Figure 4 illustrates the approved manner of recording traverse notes. The readings may be taken at a house, a turn in the road, a stream, or other prominent object, and the point roughly indicated on the perpendicular line by a short transverse line. The starting point should be thoroughly identified and in sketching line only sufficient deflection is shown at turns to indicate whether they are to the right or left. A straight line may be used adding the letters "R"

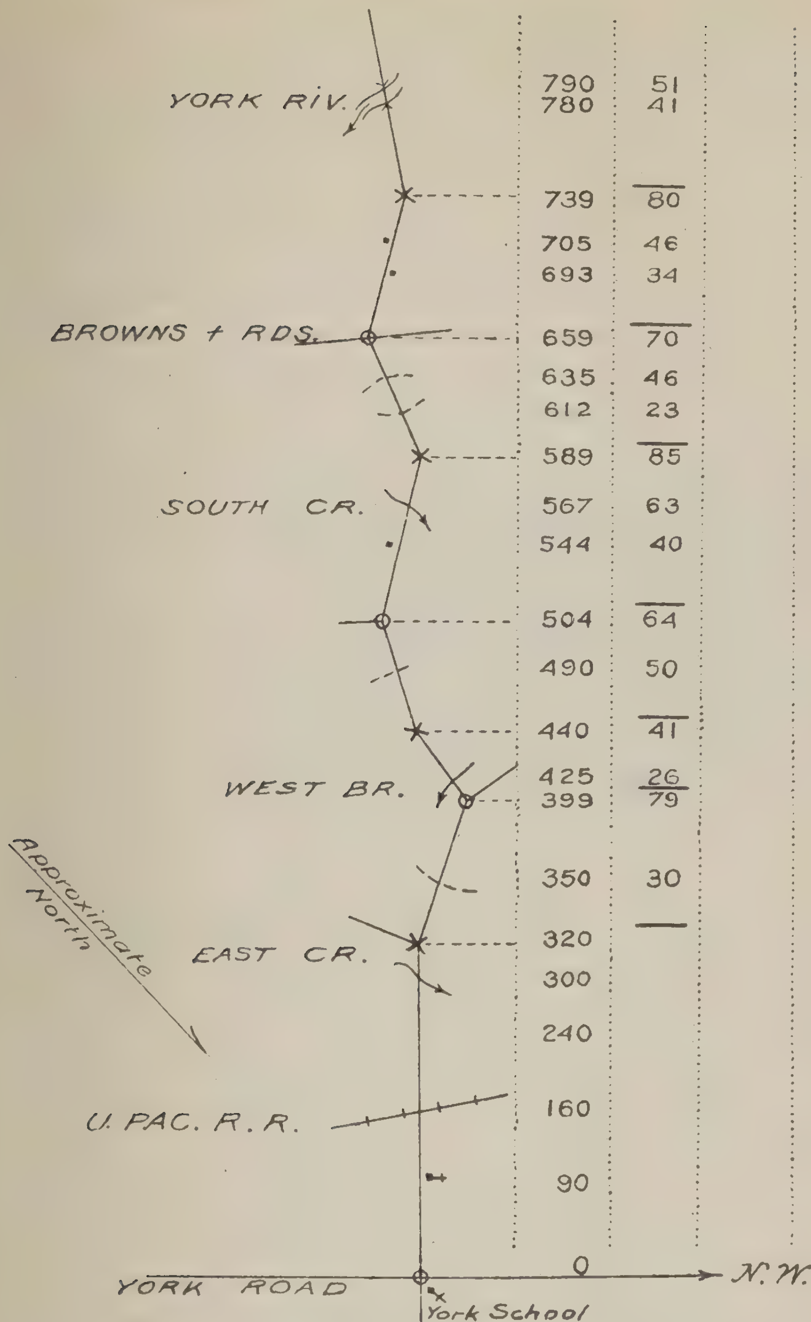

FIG. 4.—Manner of recording traverse notes.

or "L" to indicate deflection. The graphic method is, however, clearer and less troublesome. In the cut the sign × indicates set-up stations and the sign ○ the intermediate stations or turning points. The first column of figures represents odometer readings; the second column the revolutions between set-up or intermediate stations and other points, arrived at by taking the difference between a reading at a set-up or intermediate station and the reading of any other point in any given tangent. The measurement of wheel used in making traverse must be plainly indicated on the first page of the notes and thereafter at each change of vehicle. The direction of stream, soil boundaries, etc., can be conveniently indicated by the trend of these lines.

When notes are kept in accordance with the method illustrated it will be possible subsequently to check the traverse work and in this way closure or other errors may frequently be corrected in the drafting room. Field notes so kept should be turned in with traverse sheets for use of adjuster.

Determining direction.—Having described the methods used in determining distances between two points, it remains to describe the methods used for determining the direction. Direction may be determined with the planetable, with a compass with sights, or with the army sketching case. The planetable traverse is based upon the principle that when the planetable is adjusted to a north and south position and lines are drawn thereon in accordance with sights taken through an alidade, these lines will take the proper direction without the necessity of reading angles. Where the compass is used as in heavily wooded areas or rough country, the angle has to be read off from the compass and then transferred to the paper by the use of a protractor. The army sketching case combines somewhat the features of the planetable, the alidade, and the compass.

The planetable.—The planetable (see figs. 5 and 6) consists of a light wooden drawing board 15 inches square mounted on a tripod. Inserted in one edge of the board is a magnetic needle free to move through a space only of about one-half inch, protected on the top with glass, and having an adjustment on the outside which lifts the needle from its supporting pivot when not in use. At each of

the four corners of the board is a thumbscrew for holding the drawing paper rigidly against the upper surface of the table. The drawing paper in common use is a heavy paper mounted on cloth. The sheets are cut approximately the size of the planetable top with a rectangular piece cut out on the side where the compass is, so that the direction of the needle can be seen. The planetable board is attached to the tripod in such a way that it can be rotated rather easily and when set up for a sight it must also be so nearly level that the compass needle when thrown on to its pivot will move freely.

The alidade.—Accompanying the planetable and as a necessary adjunct to it is an alidade, which consists essentially of a brass or wooden ruler with at least one edge beveled for use as a straightedge in drawing straight lines on the paper. Attached to this ruler are two small sights approximately 6 inches apart which can be folded down onto the ruler when not in use. The sight that is placed nearest to the eye in operating carries a narrow slit; the sight that is farthest from the eye in operating has a wider slit in which a fine hair or silk thread is stretched in a vertical position. The alidade in common use in the bureau is made by attaching the two sights to a chain scale which has already been described and which carries on one side a scale of fiftieths of an inch, and on the other side a scale of 52.8 divisions to the inch. Figure 7 shows this alidade.

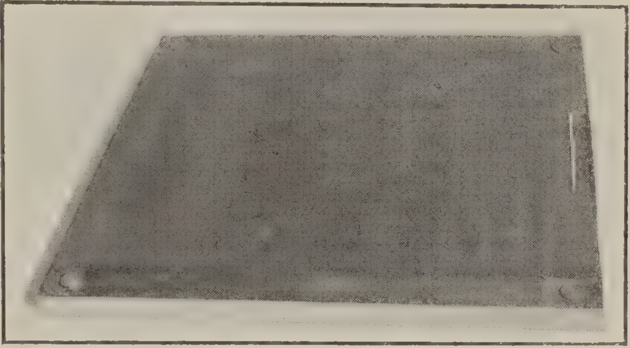

FIG. 5.—Planetable top.

In operating the planetable the first step after the table has been leveled is to swing the board until the needle of the compass is coincident with the north and south line in the compass box. This places and orients the paper in the line of the magnetic north.

A sharp-pointed No. 10 Cambric needle fitted with a convenient wooden cap or sealing-wax head is then stuck into the paper to represent the position which the planetable occupies with respect to the location of the other points on the map of the area. The straightedge of the alidade is then placed against the needle and a sight taken by rotating the alidade against the needle until the two sights of the alidade are directly in line with the distant object. Then, holding the alidade firmly down against the paper, a line is drawn from the needle point toward the object, the length of the line being eventually determined by the measured distance.

FIG. 6.—Planetable set up.

Care must be taken in all cases before taking the planetable off of its tripod support, and in all cases where the planetable is not actually in use, to throw the needle off of its pivot to avoid injury to the steel pivot point. Under no circumstances should the compass in the planetable be carried from one station to another with the needle resting on the center pin. Party chiefs should lay special emphasis on this when instructing field assistants. Leather cases are provided for the planetable and these must invariably be used to protect the planetable when the board is not actually in use on the tripod stand. In shipping the planetable it must be carefully packed and protected and the tripods should have their heads protected by hay or excel-

sior covered with a piece of sacking or other substantial cloth. The needle box should be detached, carefully packed, and shipped separately.

The accuracy of the orientation of the planetable is dependent upon the freedom from local attraction. For this reason it is necessary to avoid the use of the planetable near railroads, electric transmission lines, large bodies of steel or iron, and in certain regions of local magnetic variation. Furthermore, no plotted line should be greater than the length of the needle. It must be remembered that where the magnetic needle is used for determining direction, and where this is free from local magnetic influences and is free to move upon its pivot, the direction given is the magnetic north and south, which may differ materially from the true north and south to which the published map is to be oriented.

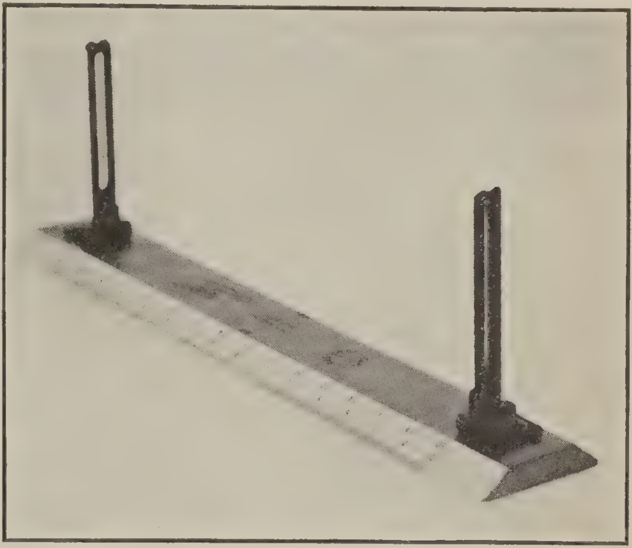

FIG. 7.—Alidade.

The sketch map (fig. 1) showing the lines of equal magnetic declinations will be used as a guide in showing deviations of the compass direction from the true north and south, and the true north and south line, determined from this map or from other sources, such as the local surveyor, as well as the magnetic north and south line as determined by the compass, should be shown upon each planetable sheet as a guide to the adjuster in the proper orientation and assembling of the sheets. This map shows the lines of equal magnetic declination in the United States as well as those of equal annual change, the former being shown by solid, the latter by dotted lines. The lines are moving westward, so that where the

declination is east it decreases and where west it increases annually. Whenever it is not possible to determine the declination from the map with a fair degree of accuracy the field man should consult the county surveyor, who can usually furnish this datum. When a large area is being surveyed it is especially desirable to do this, as the declination may vary considerably between the eastern and western parts of the survey.

Operation of the planetable.—In traversing with the planetable it is usually essential to set up the instrument only at alternate stations or points in the road. If the initial or starting point is at Station "A," (see fig. 8) the planetable is set up, leveled, and revolved until the compass needle points north and south. The alidade is placed against the needle, which is inserted at the point "A" and

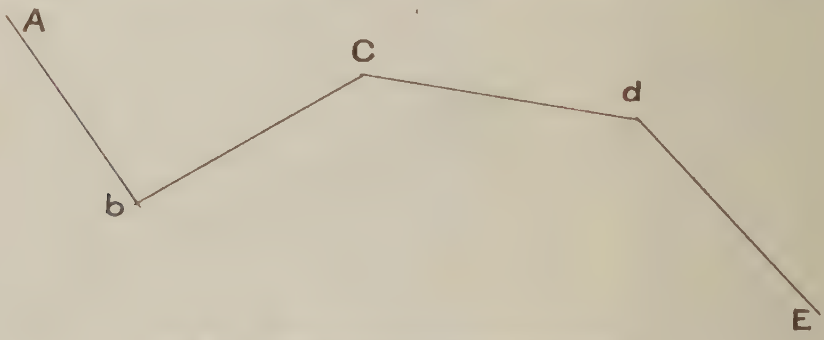

FIG. 8.—Planetable stations in road traverse.

a sight is made on the point "b." A light pencil line is then drawn with a well-pointed drawing pencil along the edge of the alidade from "A" toward "b," extending beyond the estimated distance that "b" is from "A." The odometer is read, and the reading is recorded in the notebook. The team is then driven along the road to the first bend or point "b" and another odometer reading is taken to give the number of revolutions of the wheel between "A" and "b" and the reading recorded in the notebook. The team is then driven directly to the second bend in the road or Station "C," where set-up is made. From the odometer reading recorded in the notebook the distance from "A" to "b" is plotted, and the needle is stuck at the point "b." With this as a fulcrum the alidade is rotated until the points "b" and "C" are in line and a light pencil line drawn, when from the number of revolutions of

the wheel recorded between "b" and "C" the direction and distance that "C" is from "b" can be plotted. When the point "C" has thus been placed upon the paper with respect to "b," the needle is transferred from the point "b" to "C," and the direction of "d" is determined, the distance or length of the line to be plotted when a set-up is made at "E." And so the traverse goes on by setting up at alternate turning points and making forward and back sights.

In traversing a road, houses or other points standing immediately adjacent to the road may be placed upon the map from the odometer readings, estimating the distance of the object from the road, when the distance is small. When the house or other point which it is desired to show is some distance from the road, a distance rep-

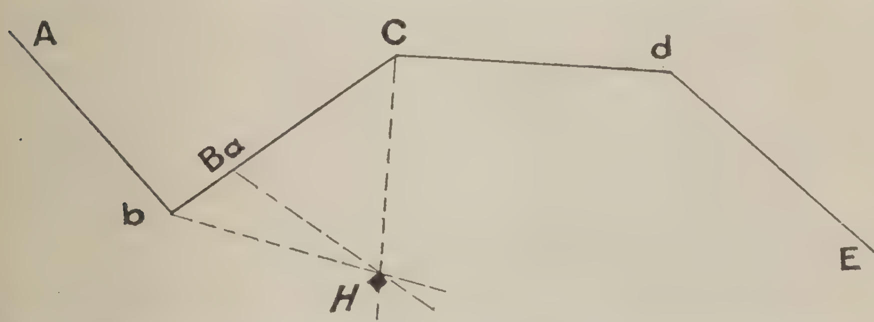

FIG. 9.—Diagram illustrating location of points by intersection during progress of road traverse.

resented by at least a number of divisions of the chain scale, it can frequently be located with sufficient accuracy by intersection or triangulation as follows: When at "b" a house "H" is seen, a sight may be taken and a line "bH" may be drawn giving the direction of "H" from "b." Similarly, from Station "C" another sight on "H" may be taken and a line drawn giving the line of direction "CH." This line will intersect the line "bH," and the point of intersection will give with sufficient accuracy the position of the house at "H." (Fig. 9.) It is obvious that the nearer a right angle the angle "bHC" is, the more accurate the location will be, as a very acute angle—such, for example, as the angle "bHBa"—may not indicate distance from "b" to "H" so accurately as the observation from "C," which cuts the line "bH" nearly at a right angle and which, therefore, locates the object "H" from the station

"b" much more accurately than would an observation from "Ba."

In traversing roads all stream crossings, cross roads, side roads, prominent trails, boundary lines, Land Office corners, railroads, trolley lines, and other cultural and prominent topographic features must be accurately indicated by the odometer reading or by foot traverse, as the case may be.

In traversing railroads the line of direction may be extended by means of fore and back sights. If in exceptional cases it becomes necessary to rely on the needle, it is important to set up the plane-table a sufficient distance from the rails to prevent their influence on the needle. In traversing a railroad distances can be obtained by measuring a rail and counting the number of rails between

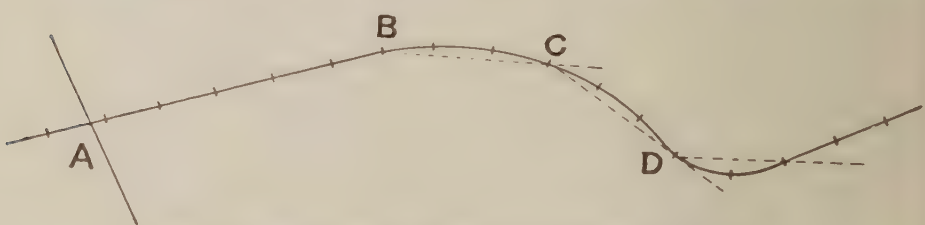

FIG. 10.—Illustrating method of traversing railroads.

set-up stations. The length of the rails must be checked before starting.

The usual method of procedure without use of compass is as follows, taking figure 10 as an illustration:

Close down compass needle and orient on highway or other previously plotted line at "A," placing planetable over rail, sight to end of straight section of road at B, count the rails (on same side of track throughout the traverse), set up at "B" and prick off distances from "A" to "B." Orient at "B" by swinging planetable until the sight through the alidade placed along plotted line "AB" corresponds with the line of sight from "B" to "A," then reverse alidade sight on break [1] in rails at "C." Work to "C," plot distance, and orient as before by sighting on break in rail at "B." Now sight ahead to next set-up station at "D," and continue in

[1] A customary method of identifying break in rails used as backsight is to choose a break near or opposite a telegraph pole or to slip a small piece of paper in the break.

this manner with the traverse, drawing lines between stations and plotting just as in highway traversing, and drawing in the curves as the work progresses. On sharp curves shorter sights should be taken.

Road lines, houses, and other lines to remain permanently on the map should be made with hard pencil, either 9 H or 6 H, and of sufficient size to be at all times legible. When the map is soft on account of dampness of the atmosphere it may be better to use a 6 H or even a 4 H pencil than the sharp-pointed, cutting edge of a 9 H.

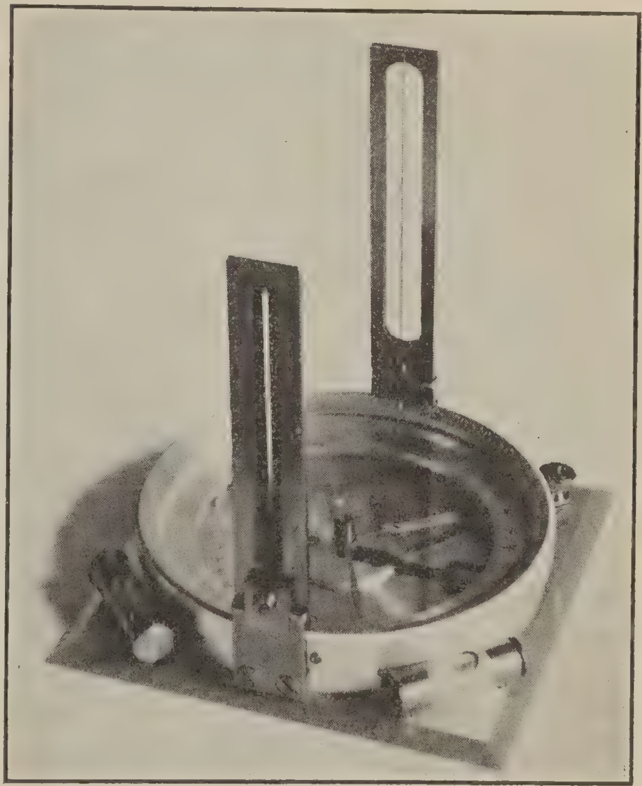

FIG. 11.—Compass.

The compass.—When the plane-table can not conveniently be used, as in densely wooded areas or rough mountain areas, and often in traversing streams, the compass with sight attachments, shown in figure 11, may be used. The compass used by the bureau has a double scale attachment, so that the inner scale may be revolved by use of a vernier to adjust for magnetic declination, so that the sighting can be given either on the basis of the magnetic north or the true north. The base of the compass is beveled and is graduated on two sides in inches and on the opposite side in degrees from 0 to 90 for use as a protractor. In sighting for direction with the use of one of these compasses, the angle obtained from the

reading of the magnetic needle on the scale is transferred to the map by the use of the protractor (fig. 12) on the base of the compass or by the use of a celluloid protractor furnished by the bureau for this purpose.

The army sketching case.[1]—The army sketching case (fig. 13) consists of a planetable board, 6 by 12 inches, to the lower right-hand side of which is attached a compass box with floating dial,

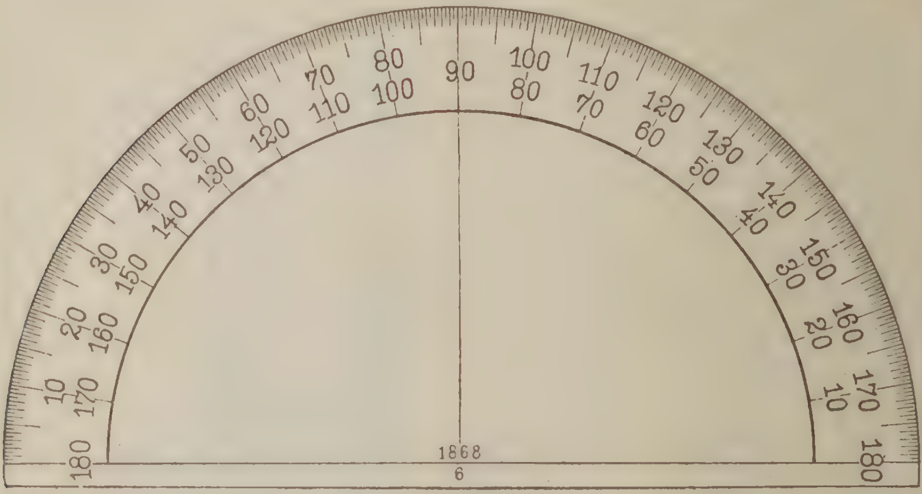

FIG. 12.—Protractor.

3 inches in diameter, beveled on the edge and graduated to 360 degrees.

A protected opening in the compass box permits the graduated dial to be read either from above or when the board is held level with the eye of the observer.

In line with the center of the compass and parallel with the edge of the board are placed rifle sights, which are used as an alidade in taking bearings.

On the upper side of the board is mounted a circular plate, 6 inches in diameter, and pivoted at the center. This plate is attached to an L-shaped base, at the upper end of which is a cylinder, through which passes a rod parallel with and secured to the top of the board.

[1] Wilson's Topographic, Trigonometric, and Geodetic Surveying, p. 166 b.

To this plate may be attached aluminum protractor cards bearing concentric scale graduations; a different card being used for each scale used in mapping. The plate and card can be slid on guides from side to side of the board and clamped at any desired position. Over this protractor travels a sheet of vellum tracing paper which is wound on friction rolls.

To sketch a traversed route or make a topographic map with this instrument, hold it level in one hand and read the compass bearing by the gun sights on some point in the route of travel.

Loosen the clamp of the circular plate carrying the protractor and revolve the plate until the degree mark corresponding with

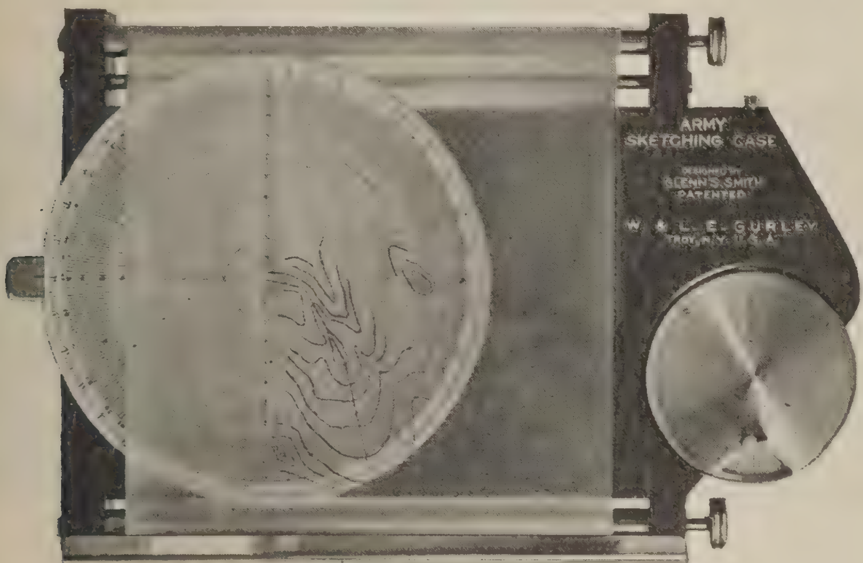

FIG. 13.—Army sketching case. (Patented.)

the bearing already determined coincides with the index line of the clamp and then clamp the plate.

The above operation insures plotting the map lengthwise of the paper.

Draw a line through the zero and 180° mark of the protractor to form the magnetic index line.

Being now prepared to proceed with the survey, sight to the point to be occupied as the next station, release the needle, and read the bearing of the dial.

Choosing a point on the paper from which the survey is to begin, place the center of the protractor exactly under it and draw a line over the radiating line on the protractor which corresponds with the bearing read by the compass.

Proceed to the station sighted and plot the distance measured by means of the radiating circles, which have a value corresponding to the scale employed.

Roll the paper on the bottom roller until the second station is opposite the center of the protractor, and move the protractor until its center is under the point occupied, and proceed as at the first station.

To locate an object lying on either side of the line of survey, read the bearing to it, and draw a short line on the paper over the

FIG. 14.—Showing large number of stations necessary in traverse work.

line in the protractor having the same numbering. On reaching the next station, again sight the object and draw a line as before. The intersection of these two lines is the location desired.

The illustration, figure 14, gives an idea of the number of stops and set-ups that it is necessary to make in the course of constructing a base map. The white dots represent the needle holes made in plotting road distances, and it will be seen that they outline the road system fairly well although no lines of connection are shown. The cut is taken from a photograph of a planetable sheet when held up to the light.

Primary control.—An important feature of a geographical map of any kind is that there shall be certain traverse lines, objects, or points, whose actual position with respect to direction and distances from each other or with respect to other objects outside of the area shall be clearly known, in order that the position and shape of the area on the earth's surface may be definitely fixed and that the direction and distances of all other points in the area may be relatively established.

The Bureau of Soils does not attempt to make this primary control as there are few areas in the United States which can not be tied up by distances and direction with points already established and obtainable from the records of the Coast and Geodetic Survey, the Geological Survey, the Lake Survey, and the surveys of the Army engineers. These records are utilized to the fullest extent and information drawn from them is furnished for use of the field men.

The base-map making by the Soil Survey field man is solely for the purpose of soil mapping. In the construction of an entirely new base map, primarily no attempt is made to construct a map strictly accurate according to the requirements of geodosy.

Maps of the General Land Office, the Coast and GoedeticSurvey, the Hydrographic Office of the Navy, the Corps of Engineers of the Army, the Mississippi River Commission, the survey of the Great Lakes, the national boundary surveys, State boundary surveys, boundaries of national parks, forests, monuments, game and bird preserves, Indian and military reservations, land grants, surveys made by the Reclamation Service, Forest Service, and Bureau of Soils, will be furnished field men when available.

The field man should not fail under any circumstances to tie his traverse to a number of such points as have been accurately located by other agencies, and the greater the number tied to the better will be the result of final adjustment of his work.

Secondary and minor control.—While the bureau does not attempt to establish primary control lines or points, but furnishes such data as are available from other recognized authorities, it is essential that the field men of the bureau tie up their traverse work with all such control points or lines as can be furnished, and with estab-

lished range, township, and section lines, railway stations, mile-posts, bridges, stream crossings, and other natural or cultural features. It is also necessary to control or check up the traverse in a number of ways.

If a traverse of a continuous road across the county is made as a base line, theoretically the road should be traversed in the opposite direction throughout its whole extent to see if the directions and distances first made are confirmed. In practice this control is obtained with less expenditure of time by running small circuits. This is done by starting from some point on the main road, preferably from a primary control station or from a section corner or cross-roads, and running with the main road for a distance of, say, 5 miles, plotting in all railroad, stream, and other crossings, then taking a side road and traversing back to the point of departure. It is seldom that a circuit of this kind extending over 10 or 15 miles will come out exact. There is nearly always a closure error. This closure error must never be adjusted by the field man but must be shown as a closure error as indicated upon the accompanying diagram (fig. 15), and the adjustment left to the office. If this closure error amounts to more than five or six scale divisions there is something radically wrong in the traverse, and the traverse in this case should be run over or the error detected in the field and indicated on the map. These closure errors must never be shown in a town or village. The errors usually occur in reading the odometer or in plotting the odometer readings on the map, and these can often be detected by comparing the odometer readings in the notebook with the plotted distances on the map and the point of error thus quickly determined, or the errors may occur from the orientation of the planetable, due either to failure to level the board so that the needle will swing free or in subjecting the magnetic needle to the influence of steel rails, buggy tires, or other magnetic influences. The utmost care must be taken in traverse work to avoid large closure errors. The two diagrams shown in figure 15 represent the traverse of a circuit of 10 or 15 miles. One of them (1) shows a closure error of less than three scale divisions, which would be considered a good traverse; the other (2) shows a closure error of considerably more than three scale divisions, which indicates a

poor traverse due to mistakes in reading or in plotting the odometer readings or to errors in taking directions; in other words, showing errors in direction or distance, or both. An expert traverse man can tell pretty closely from an examination of the work and the way the lines approach each other at the starting and ending points whether to seek for the error in the odometer readings or in the compass readings. It is helpful in the adjustment of traverse errors in the office if the direction of main traverse is shown by small

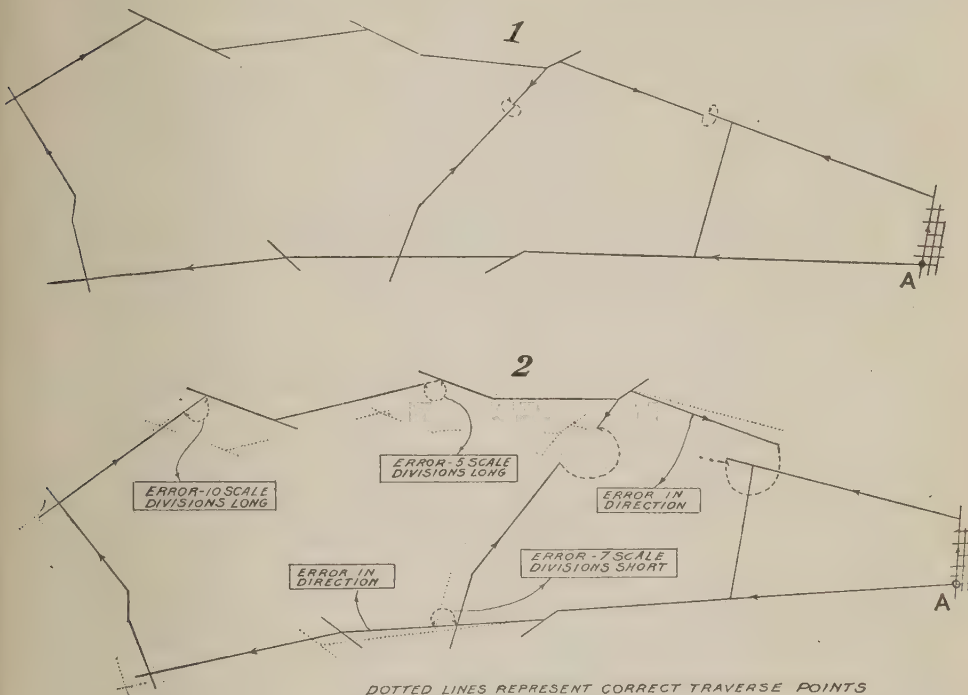

FIG. 15.—Diagrams showing good and poor traverse.

arrow points along the road in the direction traverse has proceeded. The curved arrow which is used to call attention to the closure error should always be drawn from the ending point toward the tying point and in the same direction as the arrows placed along the road. These curved arrows showing the point of closure errors should always be drawn with red ink, so as to make them distinct and to distinguish them from all pencil and black ink lines on the map. Care must be taken in working near the edges

of a planetable sheet to stop the traverse at some easily identified point, as a crossroad, a railroad crossing, stream crossing, or prominent bend in the road, which should be tied to when working adjoining sheets in order that the adjustment of the work on the different sheets may properly be made. Only one point should be transferred to an adjoining sheet, and all work on the second sheet must be started and controlled from this initial point.

When the land is sectionized no traverse line or road should be run more than 5 miles without being tied to some section or other recognized land line or corner. While it is not always possible to determine the description of any land line or corner located or pointed out, it can usually be done as a last resort by means of deeds or tax receipts. For example, where the traverseman has progressed as much as 4 miles from the last point where he tied to a land line or corner, he should begin to cast about for a tie point. On coming to a farmhouse he should explain what he is doing and ask the privilege of seeing a deed or tax receipt of the land on which the farm is located. Suppose the receipt described the tract as follows: E. $\frac{1}{2}$ NE. $\frac{1}{4}$; SW. $\frac{1}{4}$ NE. $\frac{1}{4}$; NE. $\frac{1}{4}$ SE. $\frac{1}{4}$, all in sec. 35, T. 24 N., R. 22 W. He should plat the tract described.

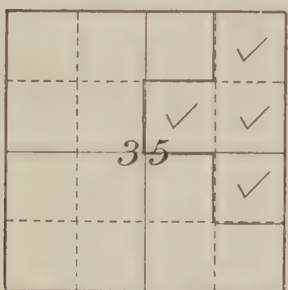

FIG. 16.—Land lines plotted from description in tax receipt.

Figure 16 is a plot of such a tract. The field man should then ask the farmer for the location of the east boundary line of his land and for the northeast corner or some other boundary line or corner. The traverse work should be tied to any corner thus located. This is an extremely important matter. The soil boundaries in such an area will be located by the user of a soil map largely by reference to section or other land lines; therefore, the more often the traverse is tied to land lines and corners the more nearly will the result desired be accomplished.

In a comparatively open (agricultural) country it is usually possible to get frequent sights on some prominent object—for instance, a church spire or peculiarly-shaped tree on a major elevation. Say the traverseman has set up or made a station at a

crossroad and located thereat a church; continuing the traverse, he would at intervals selected to give the largest angle approaching a right angle, sight back on the church spire, indicating by a short pencil line, lightly drawn, the result of each sight. For distances of one-half mile or over it is realized that the sight will be approximate only, but at the same time if care has been taken in traversing and in setting up the planetable for these reference sights, they should prove of value to the adjuster, when used in connection with the field notes giving distances, etc., stations from which

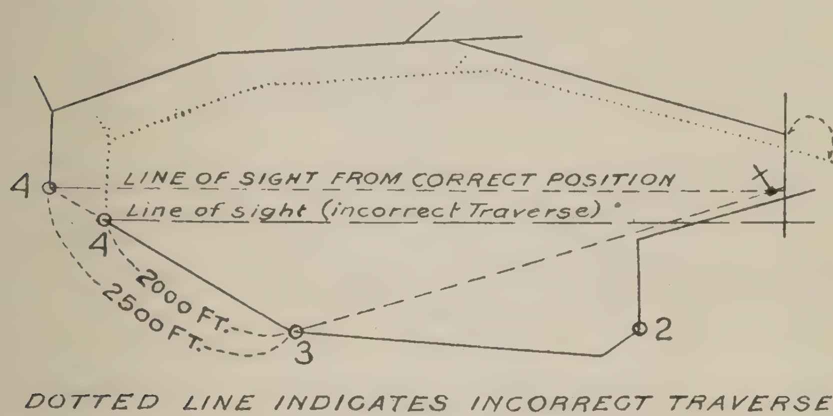

Fig. 17.—Illustrating detection of error in locating point by intersection, as a result of an incorrect odometer reading.

sights were taken on the church spire being noted in the field book. Two or three sights on a short circuit are sufficient.

In the illustration (fig. 17) the sight from station No. 3 intersects the church spire and shows the position of station No. 3 to be correct, but suppose an error has been made in plotting the line between stations 3 and 4, then upon producing the line obtained by sighting from station No. 4, the pencil line misses the spire by three scale divisions. The line of sight actually intersects the church spire, but by reason of the fact that station 4 is erroneously plotted on the traverse sheet, producing the line in pencil throws it three scale divisions south of the church for the reason that station No. 4 *on the traverse* is plotted short of the actual distance from station No. 3; i. e., the traverseman actually occupies *on the ground* the correct position, and in sighting carries a certain direc-

tion from the church, but since *on the traverse* he occupies an erroneous position south of actual station and carries the same direction from the church, the line obviously can not intersect the church spire *on the traverse*. By this means the error is promptly located, and while it might not be necessary to rerun or correct it, the traverseman would refrain from running any traverse line *away* from this portion of the circuit (from station No. 4 and beyond), but always work *back* to it, thus confining his error to the one circuit. This may be carried farther by the traverseman and he may cut in by intersection any other near-by prominent features that he is reasonably certain to see from future stations.

If a main road has originally been carefully traversed, say across the traverse sheet, to be used as a base line, then on starting the

FIG. 18.—Showing method of procedure in running circuits where a base line has already been traversed.

general traverse each diverging road should be taken up successively as reached and the circuit closed as promptly as possible. Figure 18 illustrates this procedure.

This short-circuit method would be especially useful in sections where the Geological Survey or other control is not obtainable. At the same time it should not be considered as anything more than a plan to minimize errors of secondary traverse.

The following illustration (figs. 19 and 20) shows a portion of four traverse sheets illustrating the incorrect and correct method of carrying over traverse work from one sheet to another. The extensions beyond the boundary of the map used to tie on to the adjoining sheets are indicated. These illustrations also illustrate the proper method of indicating closure errors.

As the completed map of an area must be drawn often from 10 or 15 planetable sheets and often small parts of sheets, it is very essential

that each sheet be numbered and the place occupied by each sheet shown on a diagram representing the county or area as a whole to assist in the proper assembling of the work in the office.

Features to be Shown on Map.

The features that must be shown on all of the maps are of three general classes: First, *culture* or the works of man such as roads, railroads, houses, towns, cities, etc.; second, *water*, including lakes, seas, ponds, canals, swamps, springs, etc.; third, *soils*. It is also sometimes advisable to show some of the more pronounced topographic features, as mountains, cliffs, escarpments and high terrace lines. All such features should be shown by conventional symbols and lettering.

All the work on the traverse sheets must be distinct, the lettering legible, and necessary corrections plainly indicated, so that when the work is turned over to the draftsmen it can be clearly understood by them. Strict attention to details will often save the delay of referring questions to the field men, as well as greatly facilitate the work of the office.

Cultural features.—The following cultural features are to be shown on all soil maps by the conventional signs, adopted by the United States Geographic Board for use by all mapping departments of the Government and published in Topographic Instructions of the United States Geological Survey, pages 205 to 228; bench marks, boundary lines (civil), boundary monuments, bridges, buildings, canals and ditches, cemeteries, dams, ferries, fords, land corners, land grants, land survey lines, levees, life-saving stations, lighthouses, mines and quarries, power lines, primary traverse stations, railroads, reservoirs, roads, trails, tramways, triangulation stations, tunnels, United States location monuments, United States mineral monuments, wharves, docks, jetties, etc.

Roads.—Under roads are included all streets and roads, public and private. Distinction is to be made between first-class and second-class roads, the former being shown by solid lines, the latter by broken lines. A simple method of marking consists of placing a figure or letter on each stretch of road, thus—1, standing for first

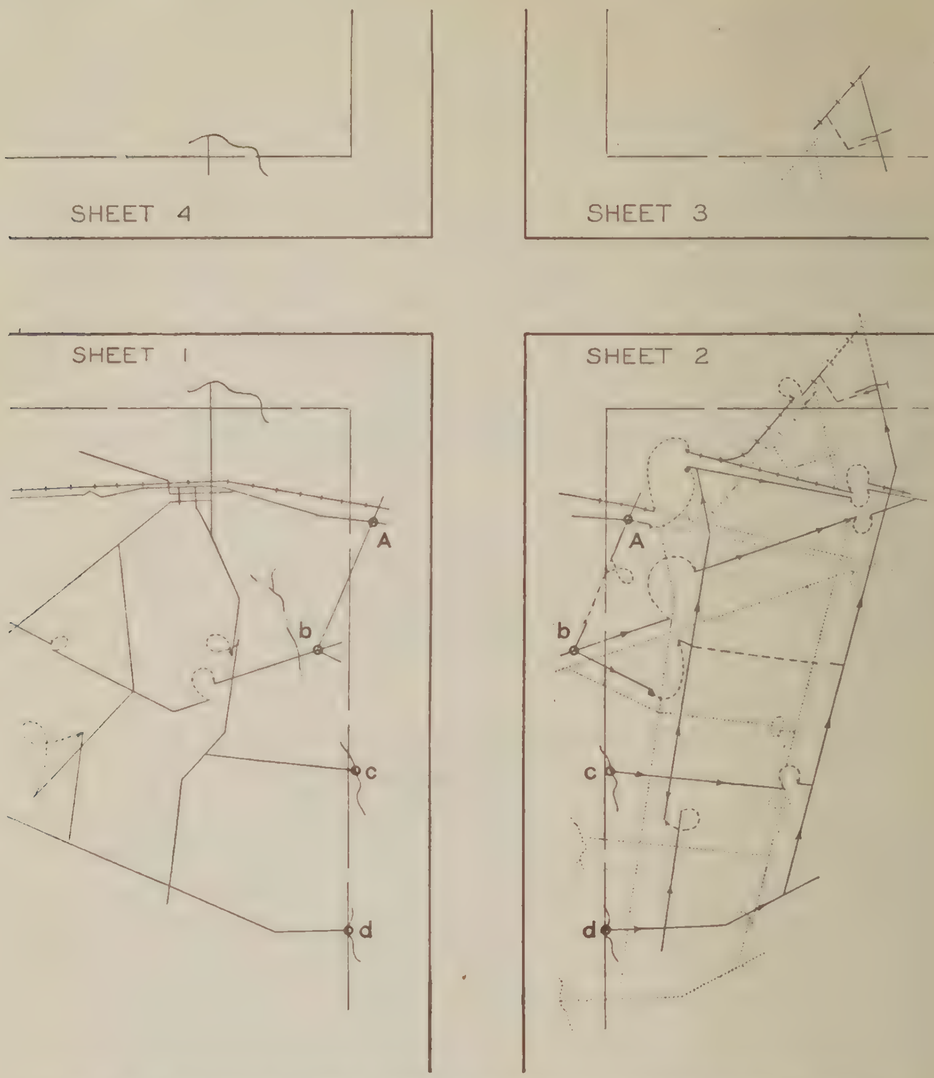

FIG. 19.—Incorrect method of carrying traverse from one sheet to another.

All points A-b-c-d along margin of Sheet No. 1 transferred to Sheet No. 2. Traverse developed on Sheet No. 2 from several of these points. Result: Errors of Sheet *No. 1* are distributed over every portion of Sheet No. 2, causing endless confusion. The dotted lines indicate traverse developed from point "A" alone (*correct method*); the full lines show development from various points "*b-c-d*" (*incorrect method*). By the second method, all errors are necessarily transferred to the various other sheets of the traverse (see sheet *No. 3*), still further adding to the confusion.]

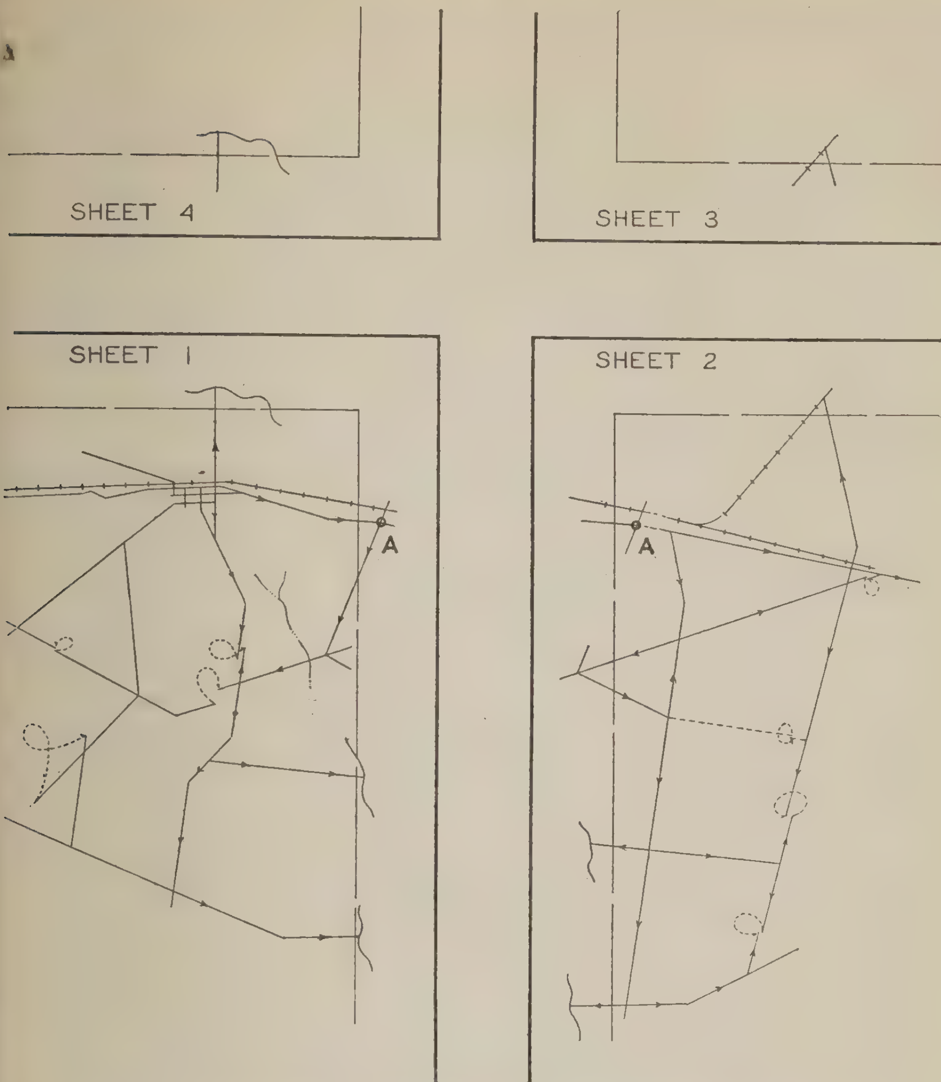

FIG. 20.—Correct method of carrying traverse from one sheet to another.

[One point only (A) transferred from Sheet No. 1 to Sheet No. 2. Traverse developed on Sheet No. 2 from this point (A) only. Traverse lines approaching margin of sheets are "stopped" at definite points, i. e., stream crossings, or intersection of roads nearest marginal guide line (on either side of same). NOTE: Sheet No. 1 shows *poor*, and Sheet No. 2 *good* traverse work.]

class; 2, for second class. This should be done as the road traverses are run.

The classification of roads is governed by the following criteria:

First-class roads include all State, county, or other public roads in such condition as to be available for travel; all main or through roads in sparsely settled mountain or desert regions, regardless of condition; all city streets and park and cemetery drives.

Second-class roads include all public roads which through disuse or neglect have become impassable or can not be traveled without risk (through roads in sparsely settled regions excepted in accordance with the foregoing paragraph); all neighborhood roads in rural districts (except those of sufficient importance to be regarded as through roads); all private roads, lanes, and stub roads to farms and country houses.

In areas where public highways generally follow the section lines of the land survey the classification of roads is to be made with reference to ownership and permanency of location, rather than condition or amount of travel. Roads which are considered permanently located include those along section lines and those which leave the section lines for short distances to avoid natural obstacles. Roads thus permanently located, when following a section line for one-fourth mile or more, are to be classed as first-class roads. Diagonal roads not following section lines here and there are to be classed as private, unless they constitute the main through routes of travel.

Lumber or wood roads generally are to be omitted, but any principal through lumber roads which may be properly considered permanent cultural features are to be shown by the second-class symbol. First-class roads should be drawn in by solid black lines, second-class roads by dotted black lines. In order that the pricked points may not be obscured it is suggested that the roads be inked up *to* the needle points, but not through them.

Buildings.—The map must show all buildings of a permanent character, such as dwellings, public buildings, shops, factories, and other industrial establishments, by proper symbols; it should be reliable not only as regards their location, but also as regards their orientation—that is, the way each building is set with respect to the points of the compass.

Uninhabitable dwellings, whether farmhouses or miner's or lumberman's cabins, are to be shown only when they constitute important landmarks in regions of sparse culture.

Houses should not be shown conventionally contiguous to the roads, unless the actual distance that separates them from the edge of the right of way can not be plotted on the scale of publication.

Detached houses in residence portions of cities, suburbs, and villages are to be shown separate wherever possible. When the scale does not permit individual houses to be shown, indicate the group by a solid block.

Churches and schoolhouses.—Churches and schoolhouses are to be indicated by a cross; such cross should be attached to the house symbol, so as to point at right angles to the roadway and not necessarily to the north. When situated in the country local name should be given.

Railroads.—Under railroads should be included all steam and electric railroads. All of these should be shown by the regular railroad symbol. Double tracks, railroad yards, spur tracks, and switches should be shown so far as the scale will permit. Separate railroad lines in juxtaposition should be differentiated by placing the crossties as shown on the symbol chart. Railroads within a roadway should be shown by fine cross lines not extending beyond the road lines.

A railroad-station should be represented conventionally by a large or elongated house symbol placed across the tracks.

Bridges.—All bridges of any consequence should be shown and the names of those across large streams should be given. Bridge symbols should be shown for all road bridges across double-line streams; all road bridges across single-line streams in sparsely settled regions or wherever the existence of the bridge is vital to the use of the road; all road bridges over canals not crossable otherwise; all important viaducts over railroads, railroad yards, roads, or streams. Ordinary bridges and trestles on railroads are to be omitted. The bridge symbol should also be omitted wherever in centers of dense culture its presence would tend to impair the legibility of the map; also on reconnoissance maps, except where it indicates important structures over streams otherwise difficult to cross.

Ferries.—Ferries are to be shown by symbol wherever the stream is wide enough to permit; otherwise the ferry is to be indicated by the word. Names of ferries must be put on the map.

Fords.—The symbol for fords is similar to that for second-class roads. The names of important fords should be put on the map.

Trails.—In mapping trails the soil man should consider their relative importance as a means of communication. Thus, in mountain and desert regions, especially in the far West, where travel is largely by trail, he should take pains to map every trail in use, giving its name, if known; in the more densely populated districts, where railroads and wagon roads are plentiful, he should show only such trails as lead up mountains or through unimproved areas not readily accessible otherwise. A mere "way through" not regularly traveled does not constitute a trail.

Canals and ditches.—Canals, whether for navigation, irrigation, or drainage, should be shown by double-line symbol only when their actual width can thus be indicated on the scale of publication; otherwise, by a single blue line. In the mapping of irrigation ditches mains and laterals are to be shown, the mains to be so designated.

Tunnels.—Tunnels of all kinds, whether on railroads, roads, or canals, should be shown by the tunnel symbol; the route of the tunnel should be indicated by double broken lines (black for railroads and roads, blue for canals).

Dams.—Permanent dams on streams, lakes, or reservoirs should be indicated by a heavy black line. Where a wagon road follows the top of the dam, the road is to be shown in its correct place, the road line on the upstream side being thickened to represent the dam.

Reservoirs.—Artificial reservoirs surrounded by dams on all sides should not be inclosed by the dam symbol, but should be outlined in blue, like lakes or ponds.

Levees.—Levees should be represented by the symbol.

Mine dumps.—All mine dumps of sufficient size to deserve mapping should be shown by symbol.

Wharves, etc.—Wharves, docks, jetties, breakwaters, and similar structures should be indicated by heavy black lines with such detail as the scale of the mapping permits.

Lighthouses, etc.—Lighthouses are to be shown by their respective symbols and life-saving stations by their name on all maps.

Cemeteries.—If of sufficient size, cemeteries should be shown with their actual outlines; if too small for this, by a square outline inclosing a cross. Small private cemeteries should be omitted.

Mines, quarries, and wells.—Maps should show the location of all mines, quarries, and wells where considered advisable. In sparsely settled regions, where there is little culture to be represented, isolated mines, quarries, and even prospects which constitute important landmarks and are widely known should be shown in black with their names.

Civil boundaries and boundary monuments.—All civil boundaries, whether National, State, county, district, civil township, reservation (National or State parks, forests, game preserves, Indian, military, or lighthouse), land grants, corporations (city, town, or borough), parks, and cemeteries, are to be shown on the map by their respective symbols. Special effort should be made by field parties to locate such boundaries with accuracy and directly from triangulation or primary traverse stations, if practicable.

Necessary descriptions, survey notes, and plats should be consulted or secured of all lines of importance. Data on National or State reservation boundaries should be obtained at or through the Washington office prior to the beginning of the field work. Data on minor civil subdivisions can best be procured locally while the survey is in progress. Many boundary monuments are obscured or obliterated by natural causes or artificial works; some are indifferently marked to begin with; others have lost some or all of their marks. The county or local surveyor or other official should be consulted in an endeavor to secure a description of the county boundaries by courses and distances, and any information secured should be furnished the office. Information from local settlers may often prove of value and save time and effort in the search for such obliterated lines. The soil man will do well to avail himself of it; at the same time he should bear in mind that the word of a resident is not to be taken as authoritative, but merely as an aid supplementing information from official sources.

All monuments on National and State boundaries should be located in the field and represented on the map with the appropriate

symbol. On other boundaries it is desirable that monuments occupying controlling positions, such as corners or important crossings, be located.

Where lines are found incorrect in azimuth and distance as the result of field errors in the original survey, it is a fundamental principle that the line marked on the ground is the de facto boundary and is to be shown on the map in its actual position, regardless of what the statute calls for. This may necessitate in some cases the accurate locating of a number of monuments so each error in the alignment may be designated at the particular spot at which it exists.

Some civil boundaries are defined by statute to follow natural boundaries, such as streams or divides between watersheds. Those following large rivers should be given special attention, as they may be variously defined as following the "middle" of the stream, its main current, or one of the banks.

Public-land surveys.—All public-land survey lines must be shown on the soil maps, and to this end it is necessary that a number of "corners" on them be accurately located in the field and shown on the field map by the proper symbol in red.

In order to expedite the work of locating corners, party chiefs must provide themselves, before taking the field, with copies of plats of the land surveys of the assigned areas. These plats should be assembled in the form of a combined plat, reduced to the scale of mapping, on tracing paper or tracing cloth. A detailed description of important corners may prove valuable in recovering them.

The soil man should be familiar with the system of rectangular land surveys and the various intricacies peculiar to it. The more conversant he is in these matters the more intelligently will he be able to make use of land-office data. Acquaintance, further, with the standard monuments used for the various classes of land corners, their marks, and their bearing or reference trees, as well as with the manner in which blazes on trees become overgrown with bark, will prove most useful both in searching for corners and in determining their authenticity where this is in doubt. (For a discussion of the public-land survey system see Topographic Instructions of the U. S. Geological Survey, pp. 183 to 192.)

Triangulation and monumental primary-traverse stations.—Triangulation and primary-traverse stations should be located and indicated on the soil maps with the open triangle symbol.

Bench marks.—All permanent bench marks located must be shown.

Black ink should be used to show all cultural features, except boundary monuments, triangulation stations, mile posts and other points to be used in adjusting and assembling the work, which should be shown in red ink.

Hydrographic features.—The hydrographic features to be shown on the maps are as follows: Shore lines, tidal flats, tidal (salt) marsh, streams—perennial and intermittent, dry stream courses, springs, wells, tanks, reservoirs, lakes, ponds, sinks, intermittent lakes, dry salt lakes, fresh marsh, and submerged marsh.

Shore line.—On all maps of the soil survey, the line of mean high tide is considered to be the shore line.

Perennial streams.—The soil man will show on his field sheets all perennially flowing streams that the scale of publication will permit; to prevent confusion in inking, his field drafting should clearly distinguish between perennial and intermittent streams.

Intermittent streams.—Intermittent streams are those having alternating pools and dry stretches, or those flowing for only part of the year.

On the field sheets the field man can not show too much of the intermittent drainage. For the engraving, to be sure, only the more important drainage courses are to be inked, but for the construction of the soil map all drainage lines are of value. Often they constitute an important element in the local distribution of soils and when shown on the map give a fairly good idea of the topographic features. Indeed, the systematic tracing out of the drainage net can not be too strongly recommended; the earlier the traverse man begins to cultivate the habit, the more successful he is likely to be in his work.

Disappearing streams.—Many streams in limestone regions abruptly sink into caverns and continue their courses for long distances through subterranean channels. Special care should be

given to the mapping of this type of drainage; the points of disappearance and reappearance should be accurately located.

Springs.—The importance of springs is dependent on their relative usefulness as a part of the water resources of the region in which they occur; and that is the criterion that should govern their mapping. Thus, although it would be entirely proper to omit springs in large numbers from maps of well-watered regions, it would be manifestly improper to leave them off from any map, even the merest reconnoissance, of desert regions.

Wells and tanks.—The importance of wells and tanks, like that of springs, depends entirely on their relative usefulness as a part of the water resources of the region. In semiarid regions both wells and tanks must be shown. Wells, if artesian, should be so designated.

Map the actual distribution of water at the time of surveying it.

Fresh-water marshes.—All fresh marsh and swampy areas occurring in soil types should be shown on the field map with fresh-water marsh and swamp symbols.

Submerged marsh.—Marsh lands that are partly submerged for many months each year are to be differentiated from ordinary marsh and represented by a special symbol combining water and marsh tufts.

All hydrographic features should be shown in blue ink.

Names to be shown.—The map should show the names of: Cities, towns, villages, and other settlements, including all country post offices and railroad stations,[1] country schoolhouses, country churches, isolated ranches constituting important landmarks in sparsely settled districts, important public institutions, such as universities and colleges, State hospitals, asylums, and penitentiaries. Steam or electric railroads,[2] highways, turnpikes, boulevards, bridges, ferries, fords, through trails, important steamboat

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[1] Where the name of a railroad station differs from that of the corresponding post office, both names should be shown, the one most widely known being given the greater prominence and the other being followed by P. O. or Sta., as the case may be.

[2] In addition to the name of the system, it is desirable, as a rule, to give the name of the branch, line, or division.

routes on large lakes, important canals, ditches, aqueducts, tunnels, dams, lakes, reservoirs, and other public works; lighthouses, and live-saving stations; parks and cemeteries; isolated mines, quarries, prospects, and oil wells; isolated furnaces and smelters; civil divisions; reservations; hydrographic features; springs, wells, and tanks, especially in arid regions where these features are of vital importance; and all relief features.

Authority for names.—The soil man should utilize local opportunities for obtaining the correct names and spelling of all features shown on the map and not resort to correspondence on this subject after his return to the office. The general policy should be to conform to local usage.

IDENTIFYING AND MAPPING SOILS.

Being provided with a suitable base map or with the knowledge and facilities for the construction of a base map, it now remains to describe how the soils are to be identified and mapped. The identification of a soil does not presuppose its mapping and may be done without reference to a base map. The determination of its distribution, however, is wholly geographic, and to show the distribution accurately it must be projected upon a reliable base map. The delineation of soil boundaries on the map may be done during the progress of base-map making and by the same man, in which case he performs three distinct functions: (1) The making of a base map, (2) the identification of soil units, (3) the delineation of soil boundaries. If he is furnished with a reliable base map he performs only the two last-named functions.

The identification of soil units or types in the area is based upon the general character of the soil and subsoil material, the general character of the topography and the physiographic situation, the source or derivation of the material, and the agencies through which the material has been accumulated.

The principal soil and subsoil characteristics to be determined in the field are: Color of soil and of subsoil—to a depth of 3 feet in the humid region and 6 feet in the arid regions, noting any change with increasing depth; texture of the soil and of the subsoil, noting such variations as occur in increasing depths; structure of soil and

of subsoil material; drainage conditions of soil and subsoil, and any marked chemical or mineralogical features.

The principal topographic and physiographic features are: Valleys, mountains, plateaus and plains, terraces, former lake beds, and river flood plains.

The principal sources or origins of material are: Granites, gneisses and schists, basalts and other quartz-free rocks, slates and phyllites, sandstones and shales, limestones, and mixed rock material.

The principal processes of accumulation of soil material are: Residual, from consolidated rocks; ice-laid, water-laid, and wind-laid.

Examination of the Soil Material.

In the work of identifying soils it is necessary to examine the material from the surface downward through a vertical section of 3 to 6 feet—3 feet, as a rule, in the humid region and 6 feet in the arid region. Sometimes it is advisable to make examinations to greater depths in order to study the substratum conditions which may have some special bearing upon the present or future worth of the soil, as, for example, to determine the depth to and altitude of a gravel bed in its relation to drainage, or, if in the arid West, to detect alkali or a heavy impervious layer which might arrest drainage to such an extent as to cause accumulations of water or alkali at the surface at some future time after irrigation has been introduced.

Examinations of the soil material are usually made with an inch and a half wood auger, which is provided with extra couplings, so that it can be extended to any desired length, and from which the cutting side flanges and the bit have been removed. (See fig. 21.) Borings are made by holding the auger in a vertical position and bearing down on it and turning it until the point has penetrated the ground to a depth of 2 or 3 inches. On pulling the auger out, a section of the soil material comes out on it in much the same condition as it existed when in place. The process of boring a few inches out at a time is repeated until the desired depth of 3 feet, 6 feet, or more is reached.

To ascertain the character of and variations in the material from the surface downward it is necessary to bore only a few inches at a time, not to exceed 6 inches in even the lighter soils, for the reason that important changes of color and other characteristics are otherwise liable to be overlooked. It is very essential that all variations in color, texture, and structure, and the occurrence of other properties within the 3-foot or 6-foot section, as the case may be, should be carefully studied and note made of them.

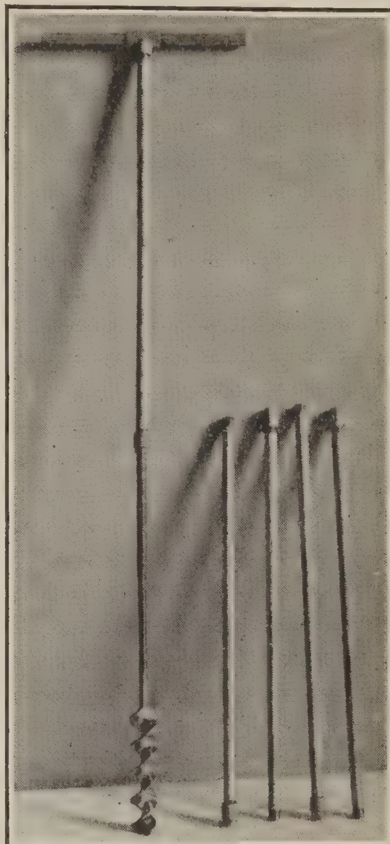

FIG. 21.—Soil auger.

Frequently it is desired to examine only the surface material to determine its color, texture, or structure. In such cases a modified form of geologist's hammer may be used to good advantage (fig. 22). The hammer also is preferable to the auger in examining very stony soils, and comes in handy in examining rocks from which the soil material is derived.

It must be remembered that the soil auger is an instrument for revealing the character of material below the surface which makes up the general characteristics of a soil. The number of borings that must be made in any given area must be left to the discretion of the field man, as the necessity for these borings depends upon the complexity of the soils of the area. In an area of obviously uniform soil conditions borings may be widely scattered. In an area of very complex soil conditions, and especially along the boundary lines, borings must often be very frequent. Often slight depressions or elevations, a change of the color of the surface material, or a change of the character of the surface or of the vegetation will indicate to the experienced soil man a change of soil

conditions to be investigated or verified by an examination with his soil auger.

At least one typical sample of soil and subsoil of each soil type must be sent in to the bureau from each area, and the sample so selected must be taken by the soil auger filling the sacks from the material adhering to the auger when it is drawn up. When the need is felt by the soil man to take samples of phases or of peculiar soil material, he should plainly indicate upon the label that such samples are sent in for special examination and that they do not represent the type as a whole. He should also state the character of examinations desired upon the label, and more fully describe them by letter.

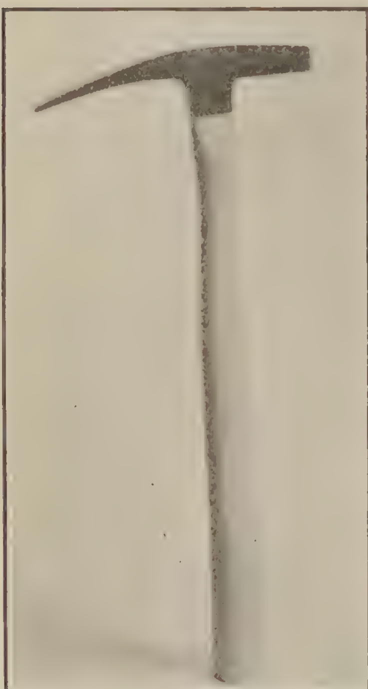

FIG. 22.—Geologist's hammer.

In collecting samples care must be taken to put into separate sacks material differing in color, texture, or other observable feature. The bureau needs but one representative sample of each soil type to serve as a basis of comparison for correlation purposes. All variations from this typical material observed in the numerous borings that are made shall be entered and described in the notebook and sent in to the bureau in this form for the information of the correlation committee, but without accompanying samples.

Borings, to determine the characteristics of the soil, should not be taken in mere spots, where the soil may represent some unimportant local variation, such as is frequently found in slight depressions, on eroded slopes, and in situations where colluvial material has accumulated. To get the type characteristics, a place should be selected in which the soil is representatively developed. The local variations, which are unmappable on the scale used,

should, of course, be examined and descriptive notes taken, so that such variations can be carefully described in the report.

While it is important to study soil sections, particularly the subsoil and substratum in road cuts, wells, and other exposures, it is generally not advisable to consider the sectional characteristics of such exposures as representing the sectional features of a type, since frequently the soil section in such places is shallower than is characteristic of the type, and the face of the section may be discolored or otherwise modified by material of colluvial creep. It is always best to take a type description from borings made at some distance from exposed sections and from minor slopes and depressions.

All borings made in the progress of the soil survey in establishing the character or distribution of a soil type should be carefully noted in the field book and the location from which the typical sample sent to the office is taken should be indicated on the base map by a small letter "s." The notes in the field book should indicate by inches, in the vertical section, any important difference of color or shade of color, and any important differences in texture, structure, rock or gravel content, and drainage condition. These notes should refer specifically to the soil, the subsoil, or to any substratum.

For the purposes of soil classification and description the soil type refers to the entire section from top to bottom, including the top soil, the subsoil, gravel beds, layers of hardpan, or a substratum, upon which the subsoil rests. For the purpose of describing the soil material of any soil type it is customary to refer to the soil, meaning the soil proper or the top soil as a layer distinguished from the subsoil. The distinction between soil and subsoil has never been clearly defined, and in some cases the distinction between the two is difficult to see. If the 3-foot soil section has the same color, texture, and other physical peculiarities throughout, it is proper to refer arbitrarily to the upper 6 or 8 inches as the soil and that below this as the subsoil. Usually, however, there is either a change of color or a change in texture between 5 to 20 inches below the surface; and where this upper part is uniform throughout, but differs in some important physical characteristic from the

underlying material, it is referred to as the soil, while the underlying material is referred to as the subsoil. Occasionally it is found that the soil material may have two layers differing slightly in color or in texture, and it is frequently found that the subsoil consists of layers differing in color, texture, structure, or drainage peculiarities.

Color.—In identifying soils color is of prime importance, being not only one of the most conspicuous features but reflecting physiological and chemical differences, as in the amount of the organic matter and of minerals which are or may be made of determining agricultural importance. Color as used in classifying and describing soils does not refer merely to the surface coloration as viewed across a field, but to the color of the soil as deep as it extends, and of the subsoil to a depth of 3 or 6 feet. What should be considered as the true color of the soil, or of the subsoil, is that which it possesses when bored out moist for examination; in other words, the color it has under normal field conditions.

As the color of the soil material is dependent upon or influenced by weathering, drainage, amount and character of organic-matter content, exposure, and cultivation, besides the mixed origin of material and a slight predominance of one material in certain places, it is not to be expected that the color of a soil will be uniform throughout its whole expanse. It is to be expected, on the other hand, that variations will occur. An effort to show the true place of a soil in a color scheme is all that can be accomplished, but in doing this, if it is attempted to give all detailed variations, confusion results and no good is accomplished. The principal soil colors are: White, black, red, yellow, gray, and brown, with shades and variations produced by different combinations, particularly of the yellow and red. The entire scheme of soil classification in the province keys of Bulletin No. 96 has been worked out practically under the following color scheme: White, black, gray, dark gray, light gray, yellowish gray, drab, yellow, reddish yellow, red, Indian red, chocolate red, pinkish red, purplish red, light red, dark red, brick red, brown, light brown, dark brown, reddish brown, and chocolate brown. Such other colors as green and blue very rarely occur, although these and other colors and other shades are occasionally found, and when found should be stated.

In other words, it has been found sufficient for purposes of soil classification and as the result of a vast amount of work done by the bureau to give certain distinctive class colors as the characteristic color of the type, and it has been found to be simpler and more satisfactory not to confuse this in the main color description by attempting to show the variations of color that may be exhibited by the soil type under different conditions of exposure and use. The Portsmouth series is properly described as a series of black soils, indicating that it belongs to a class of black soils. This distinguishes it at once from the associated Norfolk series, which is properly described as having a gray soil and a yellow subsoil. The Portsmouth series, however, throughout all its extent is not literally black. It may, under exposure and good drainage conditions, or when air dry, or with local accumulations of material, become much lighter and grayish in color. It must be remembered, however, that color is but one of the characteristics of a soil, and color may vary within limits without changing the ultimate classification of the soil material. The Cecil clay has a subsoil which is properly described as belonging to the class of red soil material. It is not always the same shade of red, but it is never a decided Indian red, as is the subsoil of the associated Penn series, nor has it the yellow color of the subsoil of the associated York series.

It will be sufficient, therefore, for the field man to determine from observation the color class, and while he should make notes of the variation in the different phases presented in the field, the official color designation of the soil material must represent the general or predominating color that is presented to him in the examination of the soil as a whole.

The color of a soil type is usually made up of two parts, the color of the surface soil material and the color of the subsoil material. Usually the color of the surface soil differs from the color of the subsoil material. Occasionally they are the same, and occasionally the subsoil is made up of layers of two or more differently colored materials. All such variations as this in the vertical section must be given, but each color so described must be a class color referring to that particular section of the profile as distinctive for the soil type as a whole.

As the samples sent in to the office for the use of the correlation committee are usually in an air-dry condition, imposing certain changes or modifications of color, it is important, to avoid misapprehension and confusion in comparing the color of the air-dry sample with the field color, for the field man to state the color of an air-dried sample in the condition it would be handled by the committee to enable the committee to judge fairly of his interpretation of color in any particular case.

It occasionally happens, as in the Guin series, where for some local reason during the accumulation of the deposit, materials of different origin, in this case, Orangeburg, Ruston, Susquehanna, and Norfolk material, have been brought together and not thoroughly mixed by the transporting agent, or when uniform weathering of the material has not occurred. The resulting soil material is so mixed and variable as to make it impossible on the scale of map used to differentiate the different classes of material. A series name is chosen to represent the series as a whole, and in this case a color description of the soil would properly be given as red, yellow, and gray, with an explanation that these color classes are variable because of variations in the material which it is impossible to outline on a map of the scale used.

In other cases, as in the northern extension of the Susquehanna series, there may be a marked variation of color occurring over a very small area, due to beds of material a few inches thick lying either in a vertical or horizontal position with markedly different colors. In this particular series it is not infrequent to find within 10 or 15 feet alternate beds of clay and sand, and alternating colors of brilliant red, deep black, bright yellow, white, and blue, and such conditions can only be described as variable color of white, red, blue, and yellow, as the case may be.

In other cases more frequently found, where drainage is deficient, the color, owing to slight differences in drainage and aeration, changes from red to yellow or gray in a single hand specimen. This condition is properly described in classification as mottled with red, yellow, or gray or other colors predominating, as the case may be.

Texture.—The texture of the soil material is determined in the field by rubbing small samples between the thumb and finger or

in the palm of the hand. The range of texture arbitrarily adopted by the bureau divides the material into 12 different classes, namely, coarse sand, sand, fine sand, very fine sand, sandy loam, fine sandy loam, loam, silt loam, sandy clay, clay loam, silty clay loam, and clay. These are determined by the different admixtures of different grades of[1] sand with silt and clay, and are determined accurately and finally by mechanical analysis in the laboratory. The official classification of material constituting each of the above grades is contained in the following table:

Classification of soil material.[2]

Soils containing −20 silt and clay:	
Coarse sand	25+ fine gravel and coarse sand, and less than 50 any other grade.
Sand	25+ fine gravel, coarse and medium sand, and less than 50 fine sand.
Fine sand	50+ fine sand, or −25 fine gravel, coarse and medium sand.
Very fine sand	50+ very fine sand.
Soils containing 20–50 silt and clay:	
Sandy loam	25+ fine gravel, coarse and medium sand.
Fine sandy loam	50+fine sand, or− 25 fine gravel, coarse and medium sand.
Sandy clay	20 silt.
Soils containing 50+ silt and clay:	
Loam	−20 clay, −50 silt.
Silt loam	−20 clay, 50+ silt.
Clay loam	20–30 clay, −50 silt.
Silty clay loam	20–30 clay, 50+ silt.
Clay	30+ clay.

[1] The sizes of the particles of the different grades adopted by the bureau and used in the mechanical analysis work are as follows:

Grade.	Millimeter.
Fine gravel	2 to 1.
Coarse sand	1 to 0.5
Sand	0.5 to .25
Fine sand	.25 to .1
Very fine sand	.1 to .05
Silt	.05 to .005
Clay	.005 to .0001

[2] The figures in this table represent per cent; the minus sign (−) and the plus sign (+) represent less or more; and the sign (-) when used between two figures, thus, 20–50, giving limiting values, should be read from 20 per cent to 50 per cent.

Care must be exercised in judging the texture of the mineral material in the presence of a considerable amount of organic matter. The presence of rock fragments or of gravel, where important as affecting cultivation or modifying drainage, should be indicated in the type name by prefixing the character of the material thus: Stony loam, gravelly loam, shale loam.

The texture of soil material is used by the bureau to apply to the particular sample of material without regard to the proximity of material of any other texture; but the texture of a soil type refers to the upper soil, as modified by the texture of the subsoil material. A sandy loam type may have a sandy loam texture throughout the 3 or 6 foot section. On the other hand, a sandy loam type may have a sandy top soil and a clay subsoil, the combination having approximately the same physical characteristics as the other as regards water-holding capacity, which is one of the most important properties of the class of soil from an agricultural standpoint. In general, the class to which a soil type belongs is defined by the texture of the surface soil to a depth of 5 to 10 inches, provided that the material to this depth has been or will be thoroughly mixed through ordinary methods of cultivation.

Generally the surface soil is lighter in texture; that is, it has less clay and more sand than the subsoil. If a change of texture comes within 2 or 3 inches of the surface, it may generally be neglected as it is likely to have little significance, especially with thorough cultivation; but when the change in texture comes at a depth of 8 to 10 inches, it is likely to be quite significant and must be considered. For example, the Cecil clay has normally from 30 to 50 per cent of clay, but nearly always in a virgin state it has 1 or 2 inches of sandy material as a surface cover which has been left as a result of superficial erosion. But when this sandy layer is 6 to 12 inches thick with the clay immediately underneath, the type becomes the Cecil sandy loam because when plowed it will still retain its surface sandy texture.

The determination of the class to which a soil belongs in a series must rest upon the judgment of the field man confirmed by the judgment of the inspector who views his work, as the mechanical analysis when made can only confirm his judgment as to the tex-

ture of any particular part of the 3-foot section, and there is no known method of measurement to determine into which class a soil as a whole which differs in texture in vertical section belongs. The field man may be guided, however, by the fact that there is always a similarity running through every soil series. Every member of the Cecil series invariably has a clay subsoil. And furthermore, when he describes a type as a sandy loam or as a silt loam or as a clay, he invariably describes the actual texture of the soil and of the subsoil separately and notes other differences in texture that are observable within the 3-foot or 6-foot section. These characteristics go to make up the full soil section and are capable of confirmation by mechanical analysis.

Structure.—When a sample is taken by means of the soil auger for the determination of color and texture the field man will also determine and make notes upon the structure of the material. The structure has a very marked influence upon ease of cultivation and the requirements of tillage operations and also upon the water-holding capacity and drainage of the soil. It is important, therefore, that the field man state from his field observation whether the material is loose and porous or compact and impervious. If any portion of the soil section is a clay, it should be determined whether this is a friable clay, a plastic clay, or a stiff clay. It may often be necessary to see the soil under both dry and wet conditions, or to bring about these conditions by wetting the sample or drying it. If the soil material has a granular structure, or, in the case of sand, if it has a loamy consistency as compared with a loose and incoherent sand, this should be stated. A silt loam may present the appearance of floury material, such as the Memphis soils, or it may have an exceedingly compact and impervious structure as the Lufkin soils have. Soil material may exhibit a stickiness which causes it to adhere to the auger or to the hand, or it may be of a more pulverulent nature with the absence of a sticky character. Certain clays are distinctly gritty; others are smooth and unctuous and readily puddled if handled in a moist or wet condition. The adobe structure is a striking characteristic of certain soils, particularly in arid regions, and may be exhibited through the range of soil classes from sandy loam to clay. Certain soils like the Manor soils of the

Piedmont Plateau derived from highly micaceous rocks exhibit a smooth, greasy feel when rubbed between the fingers. This is due to the presence of a mass of exceedingly fine mica flakes. All such structural peculiarities as this associated with the soil material are liable to have an important bearing upon the economic use of the soil.

Not infrequently there will be a compact layer encountered immediately below the zone of cultivation, locally known as hardpan, but without any definite cementing material, the compactness of the layer depending upon artificial pressure along the same horizontal plane. This is more frequently encountered where a single cropping system prevails and where the plowing has been shallow and approximately of the same depth.

Frequently, however, there are layers of true hardpan encountered at lower depths in the subsoil material. These have resulted from the cementing of soil grains by lime carbonate—in which case it is called a calcareous hardpan—or by iron material—ferruginous hardpan—or by silica itself, in which case the material is truly stonelike in appearance. Frequently these hardpan layers form at or near the junction where marked change in texture occurs. Sometimes an unbroken layer of hardpan underlies extensive areas. Occasionally there is encountered a layer of sand in the subsoil the grains of which are so rounded and saturated with water as to have the properties of a quicksand. Frequently these structural peculiarities are sufficient to constitute differences between soil series. In all soil examinations careful notes must be taken of these or other structural peculiarities, and their existence and effect on the value of the land pointed out in the description of the soil type.

Drainage.—The examination of the soil material should include the relation of the material to drainage. Where the surface soil or any portion of the subsoil shows lack of drainage the fact is usually apparent, upon boring into the soil, from the excessive amount of water encountered, but consideration should be given of course to the climatic conditions which have prevailed at the time the examination is made. In a very wet season the soil material may exhibit an unusually high water content, much higher than the

normal. In an exceptionally dry season, the soil material may show an amount of water abnormally low. The field man must judge of this from his experience and from seeing the soil under such different climatic conditions, as his stay in the area will permit, but in all cases he will be helped in his judgment by topographic and physiographic relations, by textural and structural conditions of the soil, by the color of the soil, and frequently by the mottling of the subsoil, as well as by the kind and condition of native vegetation or of cultivated crops.

The drainage conditions as affected by physiographic position, as this is expressed in the first bottom, or a second terrace, or a high terrace, is recognized as an important factor in determining the soil series. The drainage condition also has much to do with the functioning of soils and often marks their relative age as soil material. On areas of swamp the soil is yet forming. On better drained first bottom lands a more mature age of material, which often lacks distinctive soil character, is represented. The second bottom is a young soil in which the functional activities have really been established, where the assortment and mixing of material is complete, and where the circulation of water and air is normally expected to have become established more nearly as in an old soil. The old high terrace marks an advance in age, possibly to the extent of excessive drainage and excessive aeration, or even excessive erosion, which may mark the beginning of a decline in natural productivity. It is believed that the essential difference between the Portsmouth, Norfolk, and Orangeburg series is due to physiographic changes that have taken place, the maturity of the functional activities of the soil material with resultant changes in the amount and condition of the organic matter and of ferruginous material.

The drainage condition of the soil material is therefore at times a very important factor in the classification of soils, as well as an indication of the cultural requirements.

Marked chemical or mineralogical features.—Attention should be called by the field man to any marked chemical or mineralogical feature of the soil type. Reference has already been made as to the necessity for distinguishing between the different forms of

hardpan. The occurrence of highly ferruginous material either distributed through the soil or in the form of concretions or accretions on or near the surface, or the occurrence of the green mineral, glauconite, should be noted. The presence of unusual amounts of dark-colored iron or titanium minerals, the presence of unusual amounts of mica or of quartz or of feldspar, the presence of gypsum or of iron pyrites, or the occurrence of alkali salts, the methods for determining which will be given in a separate chapter, should be noted. The presence of considerable calcium carbonate as revealed by the acid test should be noted. The presence of marked acid conditions as determined by the litmus-paper test should be recorded. All such marked chemical or mineralogical features should be stated and if necessary their presence confirmed by laboratory examination.

Topography and Physiographic Situation.

While the bureau does not attempt to map topography, it is important that the field man should take advantage of all topographic maps or consider topography in its relation to soil mapping. It is particularly important, however, that he give careful attention to the topographic situation, as this will often help him to determine the source of the material and the agencies through which the material has accumulated. It is important, also, in his description of the area and for the proper understanding of the soil relation that the general physiographic features of the area be described, whether in the main or in any part of the area, the surface presents the general features of a valley, a plateau, a plain, or a rough or even mountainous condition. Such information not only leads to correct classification of soil material and of soil types, but it may have much to do with the explanation of the present or future use of the soil type.

Source and Derivation of Material.

To insure the proper classification of soils it is important to know the derivation of the material. Soil material derived directly from the disintegration of granite, talcose schist, basalt, and other quartz-free minerals, limestone, and sandstone have essentially

different properties, the reason for which may not be well understood though the facts upon which to base the classification may usually be determined. In the case of residual soils derived directly from the weathering and disintegration of solid rocks, the important guides are: Exposures of the rock itself at the surface or in road cuts, the evidence presented by geologic surveys and maps, the physiographic relationships, and the character of the soil material itself. In case of heterogeneous material which has been transported by ice, a study of the rock content of the soil or subsoil will often reveal the main character of the material from which the soil has been derived. Granitic material, sandstone and shale, limestone or basalt fragments will appear in such form and frequency as to give a fairly correct idea of the original source of the material.

In the case of soil material transported by running water or by waves in lakes or oceans, the general source of the material may be obtained by studying the physiographic position with reference to drainage basins and noting the course the material must have followed from its source to its present position. The material of the northern extension of the Coastal Plain must have been derived from the Piedmont, Appalachian, and Limestone Valleys provinces through the Potomac-Delaware-Susquehanna drainage, supplemented by a fraction of glacial material brought in through the Susquehanna and Delaware drainage ways. From the Potomac River to the vicinity of the Mississippi-Alabama line the Coastal Plain material must have been derived from the Piedmont Plateau and the Appalachian Mountain region and the Limestone Valleys, without admixture of glacial material because of the peculiar physiographic relationships that exist. In portions of Mississippi and Louisiana, built up by the Mississippi River, the Coastal Plain material is derived probably to a considerable extent from the glacial and loessial material through which the Mississippi River and its principal tributaries flow. The material in the extreme western part of the Coastal Plain, as developed in Texas, is derived principally from the shales and sandstones of the Great Plains region brought in through the drainage basin of the various streams which head in that region.

Agencies Through Which Material Has Accumulated.

Having determined the source of the material, it remains to determine the principal agencies through which the material has accumulated. The agencies recognized by the bureau as essential in the classification of soils are few and in the main are readily determined, though sometimes they are obscure and, particularly along boundary lines, may be difficult to determine. The first of these is: The weathering and disintegration in place of consolidated rocks without material subsequent movement or mixture except through local creep and erosion, giving rise to residual material. The next is the agency of moving ice and the influence of the rushing glacial waters as the ice recedes. The evidence of ice-laid accumulations is usually to be seen in the more or less stony and unsorted character of the soil or subsoil material. The evidence of ice-laid material subsequently acted upon by rushing glacial waters is sometimes more difficult to determine but is usually indicated by a broad separation of coarse residual material, flanked by plains or filled-in valleys of sand with outer zones of silt and clay. The stratification of the material as seen in the vertical section is also an important criterion. The next important agency is the wind, which has a tendency to mix materials from widely separated localities. This influence is felt more or less in all soils, but becomes sufficiently marked to serve as a basis for soil mapping in only a few definite areas. The principal evidence of wind deposition is the great uniformity in the character of the material, the fact that the body covers both hills and valleys with a blanket of comparatively uniform thickness, or that it has the form of dunes or hillocks.

The remaining agency to be mentioned is water transportation by river and wave action. Water-laid deposits will reveal their manner of accumulation through the stratification of the material, which will be nearly horizontal, and by a smooth and practically level original topography. The stratification of the material can usually not be seen in the upper 3 feet of the deposit because of the influence and effects of roots of plants, animals, cultivation, and soil creep. Soil material transported through the agency of running water is very different from the same material that has been

subjected to the influence of wave action or the distribution and segregation of the different grades of material through ocean or lake currents.

Elements of Soil Classification.

Soil provinces.—To aid in the classification of soils the United States has been divided into seven soil provinces east of the Great Plains regions and into six soil regions covering the Great Plains and the country lying between it and the Pacific Coast.[1] The soil province is an area in which the main agencies of accumulation are similar, although to a slight extent topography and origin of material have been recognized. The Piedmont Plateau Province is an area where the soils have been derived directly from the disintegration of the old crystalline and metamorphic rocks. The Appalachian Mountain and Plateau Province includes a region of peculiar physiographic form in which the soil material has accumulated mainly through the disintegration of sandstone, shale, and interbedded limestone. The Limestone Valleys and Uplands Province includes those regions in which the soil material has accumulated from the disintegration and solution of moderately pure limestones of broad extent. The Glacial and Loessial Province includes those areas in which the soil material has accumulated through the agencies of moving ice modified to some extent locally by the rushing sheet waters at the front of the receding ice mass, and deposits formed by wind. The River Flood Plains Province includes those areas in which the material has been or is now being deposited by rivers and smaller streams. The Coastal Plain Province includes the vast areas formed by material transported by streams into the ocean or along the ocean front, subjected to wave and current action with considerable separation and segregation of material, and subsequently elevated to form land. The Glacial Lake and River Terrace Province includes those areas occupied by glacial material that has been reworked and sorted out by wave and current action of the old glacial lakes and rivers, which have now largely disappeared.

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[1] The provinces and regions are shown on a map accompanying Bulletin 96, Bureau of Soils.

The soil regions of the western part of the country are separated on the basis of physiographic, geologic, and climatic differences. The Great Plains Region, the Rocky Mountain Region, and the Great Basin Region represent different physiographic areas. The Arid Southwest Region represents both a physiographic and a climatic region. The Northwest Intermountain Region represents partly a physiographic and partly a geologic condition, while the Pacific Coast Region represents a physiographic or geographic region. In any one of these soil regions one or more of the soil-forming agencies may be found: thus, in the Great Plains Region there are soils derived directly from the disintegration of sandstones, shale, and interbedded limestone; there is soil material resulting from the transportation and deposition of material by moving water; there is material which has accumulated by moving ice; and there is material that has accumulated through wind transportation and deposition. The classification into soil regions rather than into soil provinces is justified on the substantial difference in climate prevailing over the eastern and western halves of the United States and its influence upon soil character. It has also resulted from the more limited knowledge of soils, geology and physiographic relations in the western part of the United States.

Soil series.—The soil province takes into account only the broader relation of soils as regards their general origin and mode of accumulation and marked differences in physiographic features. The soil series goes a step farther and brings together all soils, in any one province, that have the same range of color of surface soils and of subsoils, the same relative character of subsoil material, particularly as regards structure (with exception of the deep sand members), the same general character of relief and drainage, and a common or closely related origin as to source of material. In each of the provinces the bureau has recognized a number of well-defined series, which are arranged and described in the text and keys of Bulletin 96.

The soil series, therefore, represents material of uniform character, origin, and mode of formation, except that it will contain material of different texture. This variation in the texture of otherwise identical or closely related material gives rise to the unit

of soil classification, the soil type. The soil series are designated by the use of local names of towns, counties, rivers, etc., usually selected from the locality where first encountered. Illustrations are the Norfolk series, the Fresno series, and the Wabash series.

Soil type.—The soil type is the individual member of the soil series based upon the difference in texture, arranged arbitrarily into 12 classes—namely, coarse sand, sand, fine sand, very fine sand, sandy loam, fine sandy loam, loam, silt loam, sandy clay, clay loam, silty clay loam, and clay.

This descriptive class term when added to the series name gives the name of the soil type and shows its place in the soil series. Thus we have the Hagerstown sandy loam, the Hagerstown silt loam, and the Hagerstown clay, indicating three classes of Hagerstown material and three types or members of the Hagerstown series. Differences not sufficient to justify a new series, such as slight differences in character of material and drainage, important variations in topography and depth of soil, the presence of hardpan and important differences in native vegetation, may be expressed in the mapping of soils as a phase, using the same color with conventional sign or symbol to indicate the phase, the basis for the recognition of a phase being given in the report.

Mapping Soils.

Soil mapping consists of outlining upon a base map the area and distribution of different types of soils. Unlike the construction of a base map, the boundaries of the soil type are usually not traversed but positions are determined with reference to cultural features, such as landlines, roads, cross roads, railroads, and houses, and to topographic and physiographic features, such as hills, valleys, and streams. In starting on the survey the field man, through a sufficient number of borings, becomes acquainted with the character of the soil type and proceeds with caution and judgment until the character of the soil material changes to another soil type. If the change in character of material from one type to the other is sharp and distinct, as is usually the case with any marked change in topography or physiographic position, the point of contact can be accurately located with respect to the nearest cultural

or physiographic feature shown upon the base map. If one type merges gradually into another, the line of separation is less easily established and judgment must be exercised in the placing of an arbitrary point in the transition zone to represent on the map the point of contact with reference to the physical features shown upon the base map. Proceeding with his work the field man will determine other points of contact, plotting the position with reference to the physical features of the base map sketching the boundary of the soil type between the established points of contact. As he becomes more and more familiar with the character of the soil type, with the origin, derivation, and agencies of accumulation and with the physiographic position, he will be greatly assisted in the delineation of his soil boundaries by a knowledge of the geology of the region, by changes in color of the surface soil, by physiographic or topographic positions, such as the meandering of streams or the position and direction of slopes or hills, and not infrequently by a change in the character of native vegetation.

The boundary line between soil types will be indicated by a fine dotted black line placed upon the base map with a hard drawing pencil and the area inclosed within the lines representing a soil type will be lightly colored by a crayon pencil and the number of the pencil will be placed on the base map in every area as well as upon a block in a legend attached to the map which is given the field name of the soil type. Great care must be used to number each area, however small, and to see that the same color is used for the same soil type wherever it occurs in the area. This is necessary in order to avoid confusion and mistakes in the assembling and redrawing of the base map in the office and to prevent error in the published map. Where phases of soil types have to be expressed the same color will be spread over the area as over the typical soil type, but rulings or conventional signs or symbols will be added without sharp boundary lines except where the phase comes in contact with different soil types.

As the soil map is frequently to be used locally, it is important that the boundary lines be adjusted with respect to landlines, roads, and houses, for the individual using the soil map in the field will locate himself not with respect to primary control points

but with respect to houses, roads, and streams. Care must be taken, especially where a soil boundary crosses a road near a closure error shown on a planetable sheet, to indicate upon the map, for the information of the draftsman, the direction from which the boundary line of the soil type has been sketched and the direction in which any adjustment must be made in the soil boundary to correspond to any adjustment that will have to be made in the road circuit.

In working away from a road where the odometer can not be used the location of the boundary line between soil types must usually be done by foot traverse or by intersection, and the boundary between points thus established must be sketched in at once in the field and never left until the day's work is finished. In other words, the delineation and mapping of the soil type must be done and completed in the field as the survey progresses, and no part of this must be done in the office or away from the point of observation.

Proceeding in this way through the area, each soil type and phase is to be outlined on the base map. In case material is encountered which differs so far from the typical conditions as to raise a question as to whether it could be mapped as a phase or whether the differences are sufficient to justify a new type, the procedure should always be to map it as a separate type giving it a field name, as upon review by the field man, by the inspector, or by the correlation committee it is much easier to combine areas separately mapped than it is to separate types in areas which have been mapped as a single type and which subsequent investigation may show should have been separated.

The smallest unit that can practically be shown upon a base map whose scale is 1 mile to an inch is 5 acres. It is impracticable to show on a base map of this scale very small areas without exaggeration. Such exaggeration is sometimes justifiable in the case of narrow meadow areas along stream courses, and occasionally where a very sharp contrast is shown in the texture or character of the soil material. On the other hand, there would be justification in the failure to map a phase or a soil condition somewhat greater in extent provided the difference is agriculturally unim-

portant, or so apparent and so frequently repeated as to constitute a general feature that might be described in the report.

It is important in order to economize time and conserve energy that the field man keep as close as possible to the actual field of work by frequently moving his headquarters, and in laying out the work ahead care should be taken to avoid driving over the same road oftener than is necessary. Careful attention to this matter of planning the work and equal attention to accuracy of detail are necessary. The speed or rate of work is an important factor in measuring the efficiency of a field man.

In the conduct of the soil survey the field men will see that they are supplied with published soil maps of any adjoining areas, and before they leave the field will prepare a note on the reasons, if any, why their work does not join up in detail with the work in adjoining areas already published.

Where topographic sheets are used alone or in conjunction with the planetable traverse the field man must verify his traverse of drainage where there is an apparent disagreement as to the direction a soil area should be extended along stream courses.

After a soil boundary has been fully established the dotted line previously drawn with a hard pencil is to be inked in indelible waterproof black ink, and before the sheet is finally sent to the office it should be carefully scrutinized to see that it is complete and legible in all details. In all cases a tracing or copy of the map must be made in the field, complete in every detail as to base map and soil map with legends, symbols, scale, and magnetic north and identification marks, and finally the field sheets, the office copy, the finished report, and all notes taken in the area should be sent under registered mail to the office, being careful to mail the field sheets and the office sheets at different times or places to insure delivery. The sheets upon which are the latest corrections should be indicated as the official copy of the soil map.

Full notes should be taken as the work progresses as to the character of the variations in the soil and as to the agriculture and other features that the field man will need in making up his final report.

Full notes should be made in the field and drawings submitted suitable for the profile legend published on the soil maps. The

construction of these drawings is best learned through a study of the profiles that have been used on any of the recently published maps. The following is a complete list of the abbreviations used by the bureau in this profile work:

Stone	St.	Madeland	Ml.
Gravel	Gr.	Marsh	Ma.
Sand	S.	Rock	R.
Loam	L.	Bed	B.
Silt	Si.	Muck	Mu.
Clay	C.	Adobe	A.
Peat	P.	Shale	Sh.
Slate	Sla.	Hardpan	Hp.
Coarse	Co.	Light	Li.
Fine	F.	Heavy	H.
Mica	Mi.	Overwash	O.
Very	V.	Riverwash	Rv.
Meadow	M.	Rock outcrop	Ro.
Black	B.	Rough stony land	Rsl.
Gray	G.	Rough broken land	Rbl.
Chalk	Ch.	Steep broken land	Sbl.
Coastal beach	Cb.	Sandhill	S. H.
Dunesand	Ds.	Tidal marsh	Tm.
Gumbo	Gu.	Igneous	I.
Gypsum	Gy.	Limestone	L.
Alluvial sediments	Als.		

INSTRUCTIONS FOR ESTIMATING AND MAPPING ALKALI.

Electrolytic Determination of Total Salts.

Principles of electrolytic determination.—The alkali content, in terms of total salts, is determined in both soils and waters by the use of the electrolytic bridge.[1]

By this instrument the electrical resistance in ohms, at 60° F., to the passage of a current through a cell filled with the soil or water in which the salt concentration is to be estimated, is determined. The resistance varies with the character and amount of

[1] For a more complete description of the principles and operation of the electrolytic bridge, see Bulletins 8, 15, and 61, and Circular 6, Division of Soils, U. S. Department of Agriculture.

the salts, decreasing as the concentration becomes greater. This rate of decrease in resistance with increase in concentrations of any one particular salt or mixture of salts may be graphically represented by a curve. Such a curve, constructed experimentally by observing the resistance corresponding to various concentrations of a salt solution, will constitute a scale or standardization curve, from which the approximate concentration of salt solutions of the same general character may be determined from the resistance readings.

When for purposes of comparison and representation upon maps the alkali or salt content of soils is grouped into zones of various degrees of concentration, the electrical resistance corresponding to the concentration limits or lines of separation will constitute a series of limiting values when applied to the interpretation of readings in terms of total salt content.

Instructions for operating the electrolytic bridge.—The irrigation water, or the soil, the electrical resistance of which is to be found, is put into the hard-rubber cell with metal electrodes. If the salt content of water is to be determined, the cell is filled even full with the water. If the salt content of soils is to be determined, the soil is placed in a cup and thoroughly mixed or worked with distilled water until a condition of saturation is reached, indicated by the appearance of free water. The cell is then filled with this material, gently tapping it on the ground to exclude air bubbles. The top of the soil is then struck off with a knife edge, so that the cell shall be just level full of the saturated soil. The cell is then suspended in the mercury cups or slipped into the spring contacts attached to the electrolytic bridge and the electrical resistance determined in the following way:

The telephone receiver is pressed against the ear and the plunger of the instrument located at the center of the dial pressed down, when a buzzing sound will be heard in the receiver. Holding the plunger down so as to keep the battery switch closed, the pointer is rotated to either right or left until the position is found at which the note in the telephone receiver is no longer heard or is only indistinctly heard. On rotating the pointer to either side of this position, the sound in the receiver should gradually increase. In

case difficulty is found in locating the exact position of balance, it will be found of assistance to rotate the pointer rapidly back and forth over the position of least sound, locating points of equal intensity on either side. The mean position between these two points gives the position of balance, and the number opposite gives the desired reading.

The sharpness of the minimum reading is much improved if the inner surfaces of the electrodes are kept clean and free from traces of grease. When waters are being tested, the cell should be occasionally cleaned with an alkaline solution or kept well scoured. The operator should avoid handling or touching the surfaces of the electrodes with the fingers.

When a balance can not be obtained near the center of the bridge, the extra 100-ohm coil of the new-form bridge described in Bulletin 61 may be used in series with the cup by rotating to the "in" position. This 100 ohms must be deducted from the resistance reading to obtain the resistance of the cup contents.

In case a balance is not obtained with the 1,000-ohm coil of the rotary switch, the 100-ohm and 10-ohm coils should be tried in succession. It is best to choose the coil which will bring the balance as near as possible to the center of the scale, as this is the most sensitive position.

Having obtained the balance, the resistance is found by multiplying the resistance of the comparison coil, as shown by the rotating switch, by the number on the scale opposite the pointer. Thus, if the comparison coil used has a resistance of 100 ohms and the reading on the scale is 0.92, the resistance in the scale is 92 ohms. If the comparison coil is 1,000 ohms and the reading on the scale is 4.5, the resistance would be 4,500 ohms. After taking the resistance in this manner, take the temperature immediately, either of the water or of the saturated soil, by sticking the bulb of a thermometer in and leaving it for some moments. The resistance is then corrected for this temperature according to the directions given below.[1]

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[1] In order to dislodge mercury from the expansion chamber at the top of the stem in the field thermometer, shake the mercury into the expansion chamber as far as possible and heat the chamber in boiling water or over the flame of a match.

Reduction of resistances to a temperature of 60° F.—A single illustration will serve to show the way the following table is used in the reduction of electrical resistances to a uniform temperature of 60° F. Suppose the observed resistance of the soil is 2,585 ohms at a temperature of 50.5°. In the table, at the temperature of 50.5°, as indicated on the left-hand side, we find that at that temperature 2,000 ohms is equal to 1,750 ohms at 60°; 5,000 ohms is equal to 4,375 ohms at 60°; hence 500 ohms would be equal to 437 ohms. Similarly, 80 ohms would be one one-hundredth of the value given for 8,000 ohms at 50.5° in the table, therefore equal to about 70 ohms at 60°, while the 5 ohms would be equal to about 4 ohms. These separate values are added together thus:

2,000	1,750
500	437
80	70
5	4
2,585 ohms at 50.5°=	2,261 ohms at 60°.

Reduction of the electrical resistance of soils to a uniform temperature of 60° F.

°F.	1000	2000	3000	4000	5000	6000	7000	8000	9000
32.0	625	1,250	1,875	2,500	3,125	3,750	4,375	5,000	5,625
32.5	632	1,264	1,896	2,528	3,150	3,792	4,424	5,056	5,688
33.0	639	1,278	1,917	2,556	3,195	3,834	4,473	5,112	5,751
33.5	646	1,292	1,938	2,584	3,230	3,876	4,522	5,168	5,814
34.0	653	1,306	1,959	2,612	3,265	3,918	4,571	5,224	5,877
34.5	660	1,320	1,980	2,640	3,300	3,960	4,620	5,280	5,940
35.0	667	1,334	2,001	2,668	3,335	4,002	4,669	5,336	6,003
35.5	674	1,348	2,022	2,696	3,370	4,044	4,718	5,392	6,066
36.0	681	1,362	2,043	2,724	3,405	4,086	4,767	5,448	6,129
36.5	688	1,376	2,064	2,752	3,440	4,128	4,816	5,504	6,192
37.0	695	1,390	2,085	2,780	3,475	4,170	4,865	5,560	6,255
37.5	702	1,404	2,106	2,808	3,510	4,212	4,914	5,616	6,318
38.0	709	1,418	2,127	2,836	3,545	4,254	4,963	5,672	6,381
38.5	716	1,432	2,148	2,864	3,580	4,296	5,012	5,728	6,444
39.0	722	1,444	2,166	2,888	3,610	4,332	5,054	5,776	6,498
39.5	729	1,458	2,187	2,916	3,645	4,374	5,103	5,832	6,561

Reduction of the electrical resistance of soils to a uniform temperature of 60° F.—Continued.

°F.	1000	2000	3000	4000	5000	6000	7000	8000	9000
40.0	736	1,472	2,208	2,944	3,680	4,416	5,152	5,888	6,634
40.5	743	1,486	2,229	2,972	3,715	4,458	5,201	5,944	6,687
41.0	750	1,500	2,250	3,000	3,750	4,500	5,250	6,000	6,750
41.5	757	1,514	2,271	3,028	3,785	4,542	5,299	6,056	6,813
42.0	763	1,526	2,289	3,052	3,815	4,578	5,341	6,104	6,867
42.5	770	1,540	2,310	3,080	3,850	4,620	5,390	6,160	6,930
43.0	776	1,552	2,328	3,104	3,880	4,656	5,432	6,208	6,984
43.5	782	1,564	2,346	3,128	3,910	4,692	5,474	6,256	7,038
44.0	788	1,576	2,364	3,152	3,940	4,728	5,516	6,304	7,092
44.5	794	1,588	2,382	3,176	3,970	4,764	5,558	6,352	7,146
45.0	800	1,600	2,400	3,200	4,000	4,800	5,600	6,400	7,200
45.5	807	1,614	2,421	3,228	4,035	4,842	5,649	6,456	7,263
46.0	814	1,628	2,442	3,256	4,070	4,884	5,698	6,512	7,326
46.5	821	1,642	2,463	3,284	4,105	4,926	5,747	6,568	7,389
47.0	828	1,656	2,484	3,312	4,140	4,968	5,796	6,624	7,452
47.5	835	1,670	2,505	3,340	4,175	5,010	5,845	6,680	7,515
48.0	842	1,684	2,526	3,368	4,210	5,052	5,884	6,736	7,578
48.5	849	1,698	2,547	3,396	4,245	5,094	5,933	6,792	7,641
49.0	856	1,712	2,568	3,424	4,280	5,136	5,992	6,848	7,704
49.5	862	1,724	2,586	3,448	4,310	5,172	6,034	6,896	7,758
50.0	868	1,736	2,604	3,472	4,340	5,208	6,076	6,944	7,812
50.5	875	1,750	2,625	3,500	4,375	5,250	6,125	7,000	7,875
51.0	881	1,762	2,643	3,524	4,405	5,286	6,167	7,048	7,929
51.5	887	1,774	2,661	3,548	4,435	5,322	6,209	7,096	7,983
52.0	893	1,786	2,679	3,572	4,465	5,358	6,251	7,144	8,037
52.5	900	1,800	2,700	3,600	4,500	5,400	6,300	7,200	8,100
53.0	906	1,812	2,718	3,624	4,530	5,436	6,342	7,248	8,154
53.5	912	1,824	2,736	3,648	4,560	5,472	6,384	7,296	8,208
54.0	919	1,838	2,757	3,676	4,595	5,514	6,433	7,352	8,271
54.5	926	1,852	2,778	3,704	4,630	5,556	6,482	7,408	8,334
55.0	933	1,866	2,799	3,732	4,665	5,598	6,531	7,464	8,397
55.5	940	1,880	2,820	3,760	4,700	5,640	6,580	7,526	8,460
56.0	947	1,894	2,841	3,780	4,735	5,682	6,629	7,576	8,523
56.5	954	1,908	2,862	3,816	4,770	5,724	6,678	7,632	8,586
57.0	961	1,922	2,883	3,844	4,805	5,766	6,727	7,688	8,649
57.5	968	1,936	2,904	3,872	4,839	5,807	6,775	7,743	8,711
58.0	974	1,948	2,922	3,896	4,870	5,844	6,818	7,792	8,766
58.5	981	1,962	2,943	3,924	4,905	5,886	6,867	7,848	8,829
59.0	987	1,974	2,962	3,949	4,936	5,923	6,910	7,898	8,885
59.5	994	1,988	2,982	3,976	4,971	5,965	6,959	7,953	8,947

Reduction of the electrical resistance of soils to a uniform temperature of 60° F.—Continued.

°F.	1000	2000	3000	4000	5000	6000	7000	8000	9000
60.0	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000
60.5	1,006	2,012	3,018	4,024	5,030	6,036	7,042	8,048	9,054
61.0	1,013	2,026	3,039	4,052	5,065	6,078	7,091	8,104	9,117
61.5	1,020	2,040	3,060	4,080	5,100	6,120	7,140	8,160	9,180
62.0	1,027	2,054	3,081	4,108	5,135	6,162	7,189	8,216	9,243
62.5	1,033	2,066	3,099	4,132	5,165	6,198	7,231	8,264	9,297
63.0	1,040	2,080	3,120	4,160	5,200	6,240	7,280	8,320	9,360
63.5	1,047	2,094	3,141	4,188	5,235	6,282	7,329	8,376	9,423
64.0	1,054	2,108	3,162	4,216	5,270	6,324	7,378	8,432	9,486
64.5	1,061	2,122	3,183	4,244	5,305	6,366	7,427	8,488	9,549
65.0	1,068	2,136	3,204	4,272	5,340	6,408	7,476	8,544	9,612
65.5	1,075	2,150	3,225	4,300	5,375	6,450	7,525	8,600	9,675
66.0	1,082	2,164	3,246	4,328	5,410	6,492	7,574	8,656	9,738
66.5	1,089	2,178	3,267	4,356	5,445	6,534	7,623	8,712	9,801
67.0	1,096	2,192	3,288	4,384	5,480	6,576	7,672	8,768	9,864
67.5	1,103	2,206	3,309	4,412	5,515	6,618	7,721	8,824	9,927
68.0	1,110	2,220	3,330	4,440	5,550	6,660	7,770	8,880	9,990
68.5	1,117	2,234	3,351	4,468	5,585	6,702	7,819	8,936	10,053
69.0	1,125	2,250	3,375	4,500	5,625	6,750	7,875	9,000	10,125
69.5	1,133	2,266	3,399	4,532	5,665	6,798	7,931	9,064	10,197
70.0	1,140	2,280	3,420	4,560	5,700	6,840	7,980	9,120	10,260
70.5	1,147	2,294	3,441	4,588	5,735	6,882	8,029	9,176	10,323
71.0	1,155	2,310	3,465	4,620	5,775	6,930	8,085	9,240	10,395
71.5	1,162	2,324	3,486	4,648	5,810	6,972	8,134	9,296	10,458
72.0	1,170	2,340	3,510	4,680	5,850	7,028	8,190	9,360	10,530
72.5	1,177	2,354	3,531	4,708	5,885	7,062	8,239	9,416	10,593
73.0	1,185	2,370	3,555	4,740	5,925	7,110	8,295	9,480	10,665
73.5	1,193	2,386	3,579	4,772	5,965	7,158	8,351	9,544	10,737
74.0	1,201	2,402	3,603	4,804	6,005	7,206	8,407	9,608	10,809
74.5	1,208	2,416	3,624	4,832	6,040	7,248	8,456	9,664	10,872
75.0	1,215	2,430	3,645	4,860	6,075	7,290	8,505	9,720	10,935
75.5	1,222	2,444	3,666	4,888	6,110	7,332	8,554	9,776	10,998
76.0	1,230	2,460	3,690	4,920	6,158	7,380	8,610	9,840	11,070
76.5	1,238	2,476	3,714	4,952	6,190	7,428	8,666	9,904	11,142
77.0	1,246	2,492	3,738	4,984	6,230	7,476	8,722	9,968	11,214
77.5	1,254	2,508	3,762	5,016	6,270	7,524	8,778	10,032	11,286
78.0	1,262	2,524	3,786	5,048	6,310	7,572	8,834	10,096	11,358
78.5	1,270	2,540	3,810	5,080	6,350	7,620	8,890	10,160	11,430
79.0	1,278	2,556	3,834	5,112	6,390	7,668	8,946	10,224	11,502
79.5	1,286	2,572	3,858	5,144	6,430	7,716	9,002	10,288	11,574

Reduction of the electrical resistance of soils to a uniform temperature of 60° F.—Continued.

°F.	1000	2000	3000	4000	5000	6000	7000	8000	9000
80.0	1,294	2,588	3,882	5,176	6,470	7,754	9,058	10,352	11,646
80.5	1,302	2,604	3,906	5,208	6,510	7,812	9,114	10,416	11,718
81.0	1,310	2,620	3,930	5,240	6,550	7,860	9,170	10,480	11,790
81.5	1,318	2,636	3,954	5,272	6,590	7,908	9,226	10,544	11,862
82.0	1,327	2,654	3,981	5,308	6,635	7,962	9,289	10,616	11,943
82.5	1,335	2,670	4,005	5,340	6,675	8,010	9,345	10,680	12,015
83.0	1,343	2,686	4,029	5,372	6,715	8,058	9,401	10,744	12,087
83.5	1,351	2,702	4,053	5,404	6,755	8,106	9,457	10,808	12,159
84.0	1,359	2,718	4,077	5,436	6,795	8,154	9,513	10,872	12,231
84.5	1,367	2,734	4,101	5,468	6,835	8,202	9,569	10,936	12,303
85.0	1,376	2,752	4,128	5,504	6,880	8,256	9,632	11,008	12,384
85.5	1,385	2,770	4,155	5,540	6,925	8,310	9,695	11,080	12,465
86.0	1,393	2,786	4,179	5,572	6,965	8,358	9,751	11,144	12,537
86.5	1,401	2,802	4,203	5,604	7,005	8,406	9,807	11,208	12,609
87.0	1,409	2,818	4,227	5,636	7,045	8,454	9,863	11,272	12,681
87.5	1,418	2,836	4,254	5,672	7,090	8,508	9,931	11,344	12,762
88.0	1,427	2,854	4,281	5,708	7,135	8,562	9,989	11,416	12,843
88.5	1,435	2,870	4,305	5,740	7,175	8,610	10,040	11,480	12,915
89.0	1,443	2,886	4,329	5,772	7,215	8,658	10,091	11,544	12,987
89.5	1,451	2,902	4,353	5,804	7,255	8,706	10,157	11,608	13,059
90.0	1,460	2,920	4,380	5,840	7,300	8,760	10,220	11,680	13,140
90.5	1,468	2,936	4,404	5,872	7,340	8,808	10,276	11,744	13,212
91.0	1,477	2,954	4,431	5,908	7,385	8,862	10,339	11,816	13,293
91.5	1,486	2,972	4,458	5,944	7,430	8,916	10,402	11,888	13,374
92.0	1,495	2,990	4,485	5,980	7,475	8,970	10,465	11,960	13,455
92.5	1,504	3,008	4,512	6,016	7,520	9,024	10,528	12,032	13,536
93.0	1,513	3,026	4,539	6,052	7,565	9,078	10,591	12,104	13,617
93.5	1,522	3,044	4,566	6,088	7,610	9,132	10,654	12,176	13,698
94.0	1,531	3,062	4,593	6,124	7,655	9,186	10,717	12,248	13,779
94.5	1,540	3,080	4,620	6,160	7,700	9,240	10,780	12,320	13,860
95.0	1,549	3,098	4,647	6,196	7,745	9,294	10,843	12,392	13,941
95.5	1,559	3,118	4,677	6,236	7,795	9,354	10,913	12,472	14,031
96.0	1,569	3,138	4,707	6,276	7,845	9,414	10,983	12,552	14,121
96.5	1,579	3,158	4,737	6,316	7,895	9,474	11,053	12,632	14,211
97.0	1,589	3,178	4,767	6,356	7,945	9,534	11,123	12,712	14,301
97.5	1,599	3,198	4,797	6,396	7,995	9,594	11,193	12,792	14,391
98.0	1,609	3,218	4,827	6,436	8,045	9,654	11,263	12,872	14,481
98.5	1,619	3,238	4,857	6,476	8,095	9,714	11,333	12,952	14,571
99.0	1,629	3,258	4,887	6,516	8,145	9,774	11,403	13,032	14,661

Concentration intervals.—The concentration limits adopted in the classification of alkali salts in the usual alkali surveys are, respectively, 200, 400, 600, 1,000, and 3,000 parts per 100,000 of total salts in the dry soil, the maps showing extent and distribution of the several grades of concentration being constructed in the field directly from field readings.

Interpretation of bridge readings.—From the results of experimental data obtained in the bureau laboratories, the following tables have been constructed from plotted curves. From these may be interpreted the values of the corrected electrical resistances in terms of the various concentrations of salts.

These values are found of sufficient accuracy to warrant their use in all reconnoissance work, and can be used in alkali surveys involving approximate determinations over limited areas, or in all alkali surveys where subject to check by independent standardization. In case unusual accuracy is required or it is found that the tables do not give reliable results, a new curve will be furnished by the bureau laboratories, or this may, if necessary, be constructed in the field according to directions which follow on page 99.

In areas in which the salts present consist predominantly of sulphates and chlorides with little or no carbonates or black alkali present the values are determined from the following table:

Concentration values of resistances in soils containing sulphates and chlorides.

Salt content (sulphates and chlorides).	Resistance at 60° F.				
	Sand.	Loam.	Clay loam.	Clay.	Average.
Parts per 100,000.	*Ohms.*	*Ohms.*	*Ohms.*	*Ohms.*	*Ohms.*
3,000	17.8	17.9	19.0	21.0	18.9
1,000	36.4	37.9	41.5	44.5	40.1
600	55.4	57.6	62.0	68.4	60.9
400	83.6	68.8	92.5	98.5	90.4
200	153.0	158.9	164.5	174.1	162.6

For general field work the averages of the following table may be used when carbonates are absent, as the values for the different classes of soil differ but slightly.

For convenience, where it is desired to determine more closely the quantities of alkali lying between those expressed in the concentration limits, the following table may be used. Where carbonates constitute a considerable proportion of the total salts present the tables on page 98 should be used in the interpretation of results.

Amounts of salts in soils containing predominantly sulphates and chlorides with given resistances.

Resistance at 60° F.	Sand.	Loam.	Clay loam.	Clay.	Resistance at 60° F.	Sand.	Loam.	Clay loam.	Clay.
Ohms.	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*	*Ohms.*	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*
18	3,000	3,000	....	....	95	350	370	390	420
19	2,400	2,640	3,000	....	100	330	350	370	390
20	2,200	2,420	2,800	3,000	105	310	330	350	370
25	1,500	1,700	1,940	2,200	110	300	320	330	350
30	1,240	1,340	1,460	1,580	115	280	290	310	330
35	1,040	1,140	1,220	1,320	120	270	280	290	320
40	860	940	1,040	1,140	125	250	260	280	300
45	750	780	880	980	130	240	250	260	280
50	670	710	770	860	135	230	240	250	270
55	600	640	690	770	140	220	230	240	260
60	550	580	630	700	145	210	220	230	250
65	510	540	570	630	150	210	210	220	240
70	480	500	530	590	155	200	210	210	230
75	450	470	500	550	160	200	200	210	220
80	420	440	470	510	165	190	200	200	210
85	390	420	440	480	170	190	190	200	200
90	370	390	410	450					

Concentration values of resistances in soils containing carbonates.

Salt content.	Resistance at 60° F.			
	Sand.	Loam.	Clay loam.	Clay.
Parts per 100,000.	*Ohms.*	*Ohms.*	*Ohms.*	*Ohms.*
3,000	23.6	24.6	24.6	30.0
1,000	54.7	68.5	69.4	96.1
600	82.6	114.8	126.2	152.5
400	131.6	168.1	201.9	216.2
200	270.6	312.3	376.2	377.4

Amount of salts in soil types containing carbonates with given resistances.

Resistance at 60° F.	Sand.	Loam.	Clay loam.	Clay.	Resistance at 60° F.	Sand.	Loam.	Clay loam.	Clay.
Ohms.	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*	*Ohms.*	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*	*Parts per 100,000*
24	3,000	....	....	....	130	410	530	590	720
25	2,900	3,000	3,000	....	135	390	510	570	690
30	2,100	2,220	2,220	3,000	140	380	490	550	660
35	1,640	1,910	1,910	2,550	145	370	470	530	630
40	1,420	1,720	1,740	2,280	150	360	450	510	610
45	1,240	1,540	1,560	2,050	155	350	440	500	590
50	1,300	1,400	1,420	1,870	160	340	430	490	560
55	1,000	1,270	1,290	1,720	165	330	410	470	540
60	870	1,160	1,180	1,600	170	320	400	460	520
65	800	1,060	1,080	1,480	175	310	390	450	510
70	740	980	1,000	1,380	180	310	380	440	490
75	680	920	950	1,290	185	300	370	430	470
80	640	860	900	1,220	190	300	360	420	460
85	590	810	860	1,140	195	290	350	410	450
90	560	770	820	1,080	200	290	340	400	430
95	540	730	790	1,010	210	260	320	380	390
100	510	690	750	970	220	240	310	370	360
105	490	650	720	910	240	210	280	340	330
110	470	630	690	870	260	190	260	320	310
115	450	600	660	830	300	....	220	280	290
120	430	570	640	790	340	....	180	230	240
125	420	550	610	750	380	....	....	200	200

Directions for making standardizations.—If greater accuracy be desired or if it be believed that the values given in the tables are

not applicable to the conditions, a standardization curve and tables may be constructed for each district or area by the following methods, reducing all resistances to the basis of 60° F. by use of the preceding tables.

For this purpose 8 or 10 crusts including the top inch of soil and so selected as to represent the average crusts of the entire area to be surveyed should be collected. If crusts can not be obtained use the strongest alkali soils collected from different places from the whole area. It is recommended that this material be immediately forwarded to the bureau with request for a standardization curve, but in cases of necessity this can be determined in the field by the following methods:

The crusts or soil samples should be thoroughly mixed together. Of this mixture take several hundred grams and add about twice its volume of distilled water. Stir thoroughly and filter off the solution. Evaporate 100 c. c. of this solution in a weighed vessel to dryness. Gently ignite to remove water of crystallization and organic matter. Allow the vessel to cool, and reweigh.[1] The gain in weight of the vessel in grams is equal to the percentage of salt in the solution. Preserve the residue in the dish to test for carbonates, or test the original solution. If the solution is stronger than 3 per cent, it should be diluted until it is of that strength; if it is weaker, it should be concentrated by evaporation until it is approximately 3 per cent. If necessary to concentrate, then determine after concentration exactly how much salt is in 100 c. c. by evaporation in a weighed vessel, as before, and make the necessary dilution of the main solution in order to obtain a 3 per cent salt content. Having obtained a 3 per cent solution, measure its resistance. Then by systematic dilution make 1.00, 0.60, 0.40, and 0.20 per cent solutions, and measure the resistance of each, reducing the values to 60° F. The dilutions may be made as follows: 33.3 c. c. of 3 per cent diluted to 100 c. c. gives 1 per cent solution; 60 c. c. of 1 per cent solution diluted to 100 c. c. gives 0.60 per cent solution; 66.7 c. c. of 0.60 per cent solution diluted to 100 c. c. gives 0.40 per cent solution; and 50 c. c. of 0.40 per cent solution diluted

[1] If care is used, weighing may be done upon druggists' scales, 15.5 grains equaling 1 gram.

to 100 c. c. gives 0.20 per cent solution. Now test the residue from evaporation for carbonates by the addition of hydrochloric acid. Carbonates will cause an effervescence. If there is little or no carbonate present, the resistances of the solution at the various percentages multiplied by the ratios in the following table for the various classes of soils give the resistances of the saturated soil with the same percentage salt content in the dry soil.

Ratio of soil resistance to solution resistance.

Sand.	Loam.	Clay loam.	Clay.
1.48	1.49	1.58	1.75
1.46	1.53	1.66	1.76
1.42	1.48	1.59	1.76
1.44	1.49	1.60	1.70
1.44	1.50	1.57	1.64
1.45	1.50	1.60	1.72

These resistances or limiting values are to be inserted in the proper place in the following tables, conversion of the salt content as expressed in terms of per cent to parts per 100,000 being made by simple calculation.

Table of limiting values.

Salt in soil.	Sand and sandy loam.	Loam.	Clay loam.	Clay.
Parts per 100,000.	*Ohms.*	*Ohms.*	*Ohms.*	*Ohms.*
3,000	....	....	....	....
1,000	....	....	....	....
600	....	....	....	....
400	....	....	....	....
200	....	....	....	....

If the test for carbonates shows that there is much of those salts present, the measured resistances for the solution should be multiplied by the ratios given in Table X, for the given concentrations,

assuming one-third the salt present to be carbonate. For exceptional accuracy, the percentages of carbonates in the salt may be determined and a corresponding new ratio, proportional to the amount of carbonate present, obtained.

TABLE X.—*Ratios of resistances of soils containing carbonates to resistances of solution containing carbonates.*

Parts per 100,000.	Sand.	Loam.	Clay loam.	Clay.
3,000	1.53	1.69	1.76	1.98
1,000	1.70	1.95	2.02	2.48
600	1.75	2.09	2.26	2.70
400	1.83	2.10	2.40	2.56
200	1.89	2.11	2.40	2.48

NOTE.—If it is desirable to determine the 3 per cent limit in the soil, portions of the composite solution will have to be concentrated by evaporation according to the above directions so as to contain the percentage of salt given in the table. The cell filled with such concentrated solutions gives a resistance too low to be read on the instrument, and it will be necessary to take a measured amount of the solution in the cell, as for example, one-fourth or one-fifth its capacity. Determine the resistance and divide it by 4 or 5, as the case may be. This gives the resistance of the cell when filled. For these concentrated solutions the readings will be rather indefinite. Keep the cell electrodes well cleaned at all times.

ALKALI MAPS.

Principles of alkali mapping.—In representing alkali areas upon the map the soils are grouped between certain arbitrary limits based upon the average amount of the alkali present in the soil to a depth of 6 feet. The alkali content is stated in terms of parts of total salts per 100,000 of the dry soil. In cases in which much greater concentrations of the total salts than would be indicated by the average amount occur locally in the surface foot or in some other section of the profile, such concentrations may be indicated upon the map by rulings or symbols as explained later.

In the construction of the usual total alkali maps the first grade, or lowest degree of concentration represented, includes areas in which the amount of total alkali salts is less than 200 parts per 100,000 of

the dry soil. This grade represents conditions under which all ordinary crops may be grown with but little or no apparent injury.

The second grade of soil includes areas containing from 200 to 400 parts of soluble salts per 100,000 of the dry soil. Soils of this grade fall within the first limits of danger, for while under favorable conditions the more hardy crops may escape injury, barren spots, or other evidences of injury to the less tolerant plants such as most grains, young or sensitive vegetables, beans, citrus, and many other fruits, are frequently observed. When accompanied by more highly concentrated accumulations at the surface, alkali crusts and barren spots may occur in fields of alfalfa or other of the more resistant crops.

The third grade covers areas in which the total salt content ranges from 400 to 600 parts per 100,000. Such concentrations are usually marked by the occurrence of frequent barren spots, by the formation of alkali crusts, the growth of characteristic alkali vegetation, and by a consequent marked decrease in yields or complete failure of crops.

In the succeeding two grades the quantity of total salts ranges from 600 to 1,000 parts per 100,000, and from 1,000 to 3,000 parts per 100,000, respectively. On land of this character there is generally a failure of all but the most tolerant crops.

The last grade of concentration in the classification embraces soils containing more than 3,000 parts of total salts per 100,000 of dry soil—a condition seldom encountered except in the barren beds of desiccated salt lakes.

Owing to the usual occurrence of a mixture of salts in varying proportions in alkali soils, the degree of injury resulting from equal concentrations varies. Only in the case of the occurrence of an excess of the sodium carbonate, or black alkali, however, is the difference so great as to require a separate basis of classification. In such case an additional black alkali map is constructed, upon which is indicated the amount of sodium carbonate occurring in the surface foot.

The lowest grade of concentration represented is less than 50 parts per 100,000 of dry soil, and like the lowest grade of the total salts is generally negligible as far as injury to crops is concerned.

The second grade embraces soils carrying from 50 to 100 parts of sodium carbonate per 100,000 of the dry soil. As with the second grade recognized in case of the total salts, occasional barren spots and unproductive areas may in such cases appear.

The third grade includes soil areas in which from 100 to 200 parts sodium carbonate to 100,000 of dry soil occur. In such areas will occur many unproductive areas occupied by the more resistant weeds and shrubs, or existing as barren spots, easily recognized by their black color and encrusted surface.

The two higher grades of concentration recognized in the classification of black alkali lands embrace soils containing from 200 to 300 parts, and more than 300 parts sodium carbonate per 100,000 of dry soil, respectively. The conditions in such soils are prohibitive of crop production under all ordinary circumstances.

Construction of total alkali maps.—Sampling for alkali determinations is done with the ordinary 6-foot soil auger, the sample being separated into foot sections and placed upon small sheets of oilcloth or similar material of convenient size. Gravel and roots or other extraneous matter are removed and the sample prepared for electrolytic determination as previously described. The location of all borings made for alkali determinations, with brief descriptions of the texture and structure of the soil, topography, drainage features, character of native vegetation, condition of crops, original resistance, cell temperature, corrected resistance, and salt content should be entered in the Alkali Field Book and the number and location of the boring indicated upon the field alkali map. The amount of alkali salts in each sectional foot of soil to a depth of 6 feet is to be determined in accordance with the directions previously given in this publication. In many cases after the observer becomes familiar with the soils and alkali conditions of a locality the field work may be materially shortened by making the alkali determinations in alternate foot sections or by mixing two or more foot sections for a single composite salt determination.

The average amount of total alkali salts is determined by computing the average of the salt contents of each of the six 1-foot sections. For representing this average amount a color is selected and applied to the map in the appropriate location, which may be

extended to additional areas of similar character as determined by further observations, additional colors being applied to represent the other recognized degrees of concentration as may become necessary. A complete legend should in all cases be shown upon the margin of the map indicating the significance of the colors used.

Careful observation of the relation of the occurrence of alkali salts to the prevailing soil types, to topography, to drainage features, character of native vegetation, and the condition of crops will aid greatly in locating boundaries defining the areas of the several grades of alkali in soils.

In case there should be a marked accumulation of the alkali salts at any one part of the vertical section as in the vicinity of the surface, or in an underlying hardpan, the judgment of the observer is to decide whether the strict mathematical average should be followed or whether the soil is to be mapped as of the next higher grade of alkali content.

If such local accumulations be of considerable extent they may be indicated upon the total alkali map by special rulings or symbols laid on over the color indicating the average salt content and explained in a special legend. Thus, if a soil contains an average of 200 parts per 100,000 of total alkali salts, but has an accumulation of 500 parts per 100,000 of total salts in the surface foot, this soil should be colored to indicate an average total salt content of 200 parts per 100,000 of dry soil, and the fact that there is a more highly concentrated surface accumulation indicated by rulings across the area affected.

Determination of carbonates, bicarbonates, and chlorides in soils.[1]—Fill the small brass cone found in the field outfit or other vessel of approximately the same size and of known volume with the saturated soil as prepared for electrolytic determination. Place cone in the neck of a 200 c. c. bottle or flask, wash the contents into the bottle, fill to the mark with distilled water, shaking thoroughly, and then filter, discarding the first 50 c. c. of filtrate in order to eliminate errors from the introduction of previous solutions retained in the porous tube of the filter pump. Titrate 50 c. c. of the solution,

[1] See Bulletins 18 and 31, Bureau of Soils, for more complete directions and discussion of this matter.

representing one-fourth of the total volume of saturated soil, with N/20 acid potassium sulphate containing 6.811 grams per liter, using phenolphthalein as an indicator. This will represent the carbonates. Then add a drop or so of methyl orange or congo red and again titrate with N/20 acid potassium sulphate. Subtract an amount equal to the first titration from the second, and the difference represents the bicarbonates. Add a few drops of potassium chromate as an indicator to the same solution and titrate with N/10 silver nitrate. This will represent the chlorides. The salts are all to be estimated as sodium salts, as follows:

1 c. c. N/20 $HKSO_4$ is equivalent to 0.005305 gram Na_2CO_3.

1 c. c. N/20 $HKSO_4$ is equivalent to 0.004203 gram $NaHCO_3$.

1 c. c. N/10 $AgNO_3$ is equivalent to 0.00585 gram NaCl.

Construction of black alkali maps.—In areas where the construction of a black alkali map is warranted, the classification of the soils into the various grades of concentration is effected in the field from the volume of N/20 acid potassium sulphate used in titration for carbonates in the surface foot, the various grades being represented by selected colors as in case of the total alkali map. The limiting values corresponding to the concentration grades of less than 50 parts, 50 to 100 parts, 100 to 200 parts, 200 to 300 parts, and more than 300 parts sodium carbonate per 100,000 of dry soil, in terms of the number of cubic centimeters N/20 acid potassium sulphate used in titration, are determined as follows:

Each of the brass cones accompanying the alkali field outfit is stamped with its volume capacity in cubic centimeters. When this amount is diluted to 200 c. c. in the flask or bottle and 50 c. c. of this volume of solution taken for titration, the volume of soil represented by the solution used in titration will amount to one-fourth the volume of the cone. Should the volume of the bottle or flask used in making up the soil solution be greater or less than 200 c. c., the volume of soil represented by the amount taken for titration will be greater or less than one-fourth the contents of the cone, and should be computed.

This volume of saturated soil represented by the amount of solution taken for titration should now be multiplied for the various

concentration intervals and for the various classes of soils by the factors in the following table:

Na_2CO_3 in soil.	Sand and sandy loam.	Loam.	Clay loam.	Clay.
Parts per 100,000.				
300	0.832	0.752	0.720	0.689
200	.554	.502	.480	.459
100	.277	.251	.240	.230
50	.138	.125	.120	.115

The results thus obtained are the number of cubic centimeters of N/20 acid potassium sulphate solution used in titrating the carbonates, corresponding to the concentration limits and are to be inserted in the following table:

Na_2CO_3 in soil.	Sand and sandy loam.	Loam.	Clay loam.	Clay.
Parts per 100,000.	*c. c.*	*c. c.*	*c. c.*	*c. c.*
300	....	....	....	....
200	....	....	....	....
100	....	....	....	....
50	....	....	....	....

If it is desired to reduce the volume of N/10 $AgNO_3$ to per cent or amount in terms of parts per 100,000 of NaCl in dry soil, the following formula may be used:

$$\frac{V\ 0.00585}{V'\ K}$$

Substituting 0.004203 for 0.00585, the same formula may be used to reduce the volume of N/20 $HKSO_4$ to per cent of $NaHCO_3$. V= cubic centimeters N/10 $AgNO_3$ or N/20 $HKSO_4$ solution used; V′=volume saturated soil represented in amount of solution titrated; K=constant for type of soil as follows: Sand and sandy loam=1.46; loam=1.32; clay loam=1.26; clay=1.21.

Determination of Total Salts in Water.

The total salt content of irrigating, drainage, or other waters, in parts per 100,000, may be determined within a reasonable degree of accuracy from the following table, the resistance at 60° F. being ascertained according to the directions given in the preceding pages. The curve varies according to the character of the salts present. Where no carbonates are present in the water, the figures in the column marked "Chlorides" should be used. When preliminary examination by titration indicates that more than 50 per cent of the total salts is carbonates, the figures in the column marked "Carbonates" should be used. For intermediate percentages of carbonates, a corresponding intermediate value between those given in the two columns should be used.

For using the bridge with water or soil solutions, the cup is filled with the solution and the reading of resistance made just as with soils. After correcting for temperature, the parts per 100,000 of salt in solution are determined by use of the following table:

Table for determining total salt content of water from resistance at 60° F.

Resistance 60° F.	Chlorides.	Carbonates.	Resistance 60° F.	Chlorides.	Carbonates.	Resistance 60° F.	Chlorides.	Carbonates.
	Pts. per 100,000.			*Pts. per 100,000.*			*Pts. per 100,000.*	
30	750		140	141	200	340	50	71
35	670		150	132	187	360	47	65
40	595		160	124	176	380	44	60
45	525		170	116	165	400	41	55
50	460	460	180	109	154	450	35	46
55	400	425	190	102	144	500	31	38
60	355	395	200	96	138	550	28	32
65	305	375	210	91	130	600	25	27
70	265	355	220	87	122	700	22	23
75	230	335	230	83	116	800	20	
80	213	320	240	79	110	900	19	
85	203	306	250	75	105	1,000	18	
90	195	294	260	71	100	1,200	17	
95	188	284	270	68	95	1,400	16	
100	181	262	280	65	90	1,600	16	
110	170	250	290	62	86	1,800	15	
120	160	231	300	59	83	2,000	15	
130	150	213	320	54	77			

The electrolytic cells are made as nearly of the same dimensions as possible, but if there is much variation in either volume or shape this table must not be used without a correction for the cell.

If greater accuracy is desired than can be expected by the use of the above table, proceed in the following way:

Collect 6 or 8 samples of water from different parts of the area, determine the electrical resistance of each, and take an amount of each proportional to the resistance, mixing them in a clean vessel. There should be at least 2 quarts, and preferably 1 gallon, of this mixture. Evaporate slowly on a stove until the mixture is about as strong as the strongest water likely to be encountered. If there is any possibility of encountering water as strong as a 1 per cent solution—that is, 1,000 parts of salts in 100,000 parts of water—the mixture should be evaporated until it gives a resistance in the cell of about 23 ohms. The amount of this evaporation can be determined by the original resistance of the mixture. If the resistance of the mixture is 100 ohms, it should be evaporated to one-fourth its volume to make approximately a 1 per cent solution. If the resistance is 400 ohms, the solution should be evaporated to one twenty-third of its original volume. Water having a resistance of 400 ohms would have a salt content, according to the above table, of about 44 in 100,000, and would be considered an excellent water for irrigation purposes. It would require 3 gallons of such water evaporated to 1 pint to make a 1 per cent solution.

Determine the percentage of salts in this solution by evaporation to dryness. If necessary, the weights may be determined by weighing on druggist's scales.

Take the concentrated solution and dilute with successive quantities of distilled water, so as to change the concentration of the solution and get the corresponding resistances in the cell. Use, for example, 9 parts of the solution and 1 part distilled water, then 8 parts of the solution and 2 parts of distilled water, and so on down to any dilution likely to be encountered. This will give the resistance corresponding very exactly with known amounts of salt, and will furnish a table for the estimation of the salt content from the resistance of any water in the area.

The table constructed from these data can be used directly by interpolation, or preferably a curve should be constructed and any intermediate points picked out from this.

Care of Electrolytic Bridge.

The bridge is a delicate instrument, and care should be exercised that it is not damaged by persons unfamiliar with its construction and use. It should not be subjected to any knocks and jars that can be avoided. By rough handling the connections are liable to be broken, the balancing mechanism injured, or parts jostled out of place. The accumulation of dust on its parts may be injurious, hence the box should not be left open when not in use. The bridge wire should be occasionally wiped off with a soft cloth to remove dust that may have collected on it. All the contacts should be occasionally cleaned. Dust on the interrupter of the induction coil may cause trouble. It may be cleaned with a fine brush or soft cloth. Should any of the soldered connections of the bridge be broken, the bridge should be sent to an electrician for repair.

Testing the bridge.—The introduction of the 100-ohm coil (cup coil) in the arm of the bridge with the cup is useful not only in making measurements on concentrated solutions but also to test the correctness of the bridge. In place of the cup a heavy metal piece supplied for the purpose connects the cup clips. On throwing in the extra 100-ohm coil it is the only resistance in that arm of the bridge and should be balanced by 100 ohms in the known arm. If the bridge is in working order, but if the 100 ohms in the cup arm are not balanced by 100 ohms in the comparison coil arm, then correction must be made for the difference. Should the difference be very great, the bridge is probably out of order and should be repaired by a competent electrician.

Location of faults.—The bridge is so designed that it may have the least possible likelihood of damage, but occasionally it may fail to work. Some probable causes for this are as follows:

On pressing down the plunger no sound may be heard in the telephone receiver for any of the following reasons: (1) An exhausted battery; (2) lack of contact of the points in the battery switch, due to dirt thereon; (3) improper adjustment of the current interrupter; (4) broken connections; (5) failure of the contact spring of the balancing mechanism to make contact with the bridge wire; (6) trouble with the telephone.

If on closing the battery switch the interrupter gives a buzzing note but no sound is received in the telephone, the trouble can not

be in the battery or interrupter. If the interrupter does not work, see that the switch contacts are clean; then examine the interrupter. By adjusting the screw of the interrupter it can be made to work if the battery is all right. If it does not work, examine the connections of the battery and induction coil. If these are good, then the battery must be replaced by a new one. Should the interrupter work satisfactorily, but no sound be heard in the telephone receiver, a broken circuit exists or the telephone may be out of order. The broken circuit can be found usually by carefully examining the connections. If the difficulty appears to be in the bridge wire, the bridge-wire slide should be examined and adjusted, if necessary, by carefully turning the set screw. When a note is heard in the receiver for a part of the scale only, the trouble is with the bridge-wire contact. In case the fault seems to be in the receiver the connections inside the bridge box should be examined, and then the screws binding the cord terminals. If these are satisfactory, the receiver should be tested directly on the battery circuit.

If the fault is not located by any of the above means, the trouble must be inside the coils. Under such circumstances it is unwise to attempt to remove the trouble by such means as are at hand in the field, and the bridge should be sent to a professional instrument maker or electrician for repair.

Determination of carbonates, bicarbonates, and chlorides in water.—When water is examined by chemical methods, as described in the preceding pages, 50 c. c. of water should be used in making the titration. Calculation of results may readily be made from the following table:

C. c. N/20 $KHSO_4$ or N/20 $AgNO_3$.	Parts per 100,000 of water.		
	Na_2CO_3.	$NaHCO_3$.	NaCl.
1	10.53	8.34	11.61
2	21.06	16.69	23.22
3	31.60	25.03	34.84
4	42.13	33.38	46.45
5	52.66	41.72	58.06
6	63.19	50.06	69.67
7	73.72	58.41	81.28
8	84.26	66.75	92.89
9	94.79	75.10	104.51

Qualitative Determination of Alkali Salts.

Should a further field examination of crusts, minerals, concretions, or other substances appear desirable as supplementary to the ordinary field tests, or as preliminary to laboratory analysis, the following simple methods may be used:

Calcium.—To about 25 c. c. of the filtered soil solution add a little concentrated hydrochloric acid, and then enough ammonia water to impart a perceptible ammoniacal odor. Should a precipitate be formed redissolve in hydrochloric acid and again make alkaline with ammonia water. Repeat the alternate addition of hydrochloric acid and ammonia water until no white precipitate is formed when the solution is alkaline with ammonia. Then add a few crystals of ammonium oxalate and heat to boiling. Allow to stand a few minutes. A white precipitate shows the presence of calcium. A slight turbidity indicates small amounts of calcium.

Magnesium.—Filter off the calcium precipitate on a small filter, cool the filtrate, and add a few crystals of sodium phosphate. Shake to dissolve the phosphate, then add ammonia water equal in amount to about one-third of the volume of the liquid, and let stand for at least one hour. A white crystalline precipitate shows the presence of magnesium. The precipitate is rather slow in appearing when the magnesium is present in small quantities, and may be hastened in forming by scratching the sides of the vessel with a glass rod, in which case the precipitate will appear first on the scratched places.

Sodium and potassium.—Quite small quantities of these metals may be detected by the flame test. Clean the platinum wire by dipping in hydrochloric acid and heating in the colorless flame of the alcohol lamp until it no longer colors the flame. An ordinary candle or lamp flame can not be used. Then dip the lopped end of the wire in the soil solution or solid salt to be treated and put into the flame. A strong yellow color shows the presence of sodium. The violet color of the potassium is masked by the intense yellow of the sodium, and this color must, therefore, be screened out by looking at the flame through blue cobalt glass. The potassium, if present, is then recognized by the violet color of the flame.

Chlorides.—Add sufficient acid (preferably $HKSO_4$) other than hydrochloric acid to decompose the carbonates. Add silver nitrate, which gives a white insoluble precipitate of silver chloride which is soluble on the further addition of ammonia water. The addition of the acid is necessary, since silver carbonate is also a white insoluble precipitate.

Sulphates.—Add sufficient hydrochloric or nitric acid to decompose carbonates. Unless a decided excess of acid is added it will be necessary to boil the solution. The addition of barium chloride will then precipitate insoluble white barium sulphate.

Carbonates.—Dissolved carbonates are recognized by the red color imparted to the solution by phenolphthalein indicator.

Bicarbonates.—Dissolved bicarbonates are distinguished from carbonates in that they produce no reaction with phenolphthalein indicator, but show a yellow color with methyl orange indicator, which must not change to a red on the addition of one or two drops of the N/20 $KHSO_4$ solution. The volume of the N/20 $KHSO_4$ solution used is a measure of the amount of bicarbonate as explained under the quantitative method for bicarbonates.

Nitrates.—Add some crystals of ferrous sulphate to the solution. Hold the test tube at a slanting angle and pour, very carefully, concentrated sulphuric acid against the lower sides of the tube so that it will run to the bottom and form with the original solution two liquid layers. The formation of a brown ring indicates the presence of nitrates. Care should be taken not to shake the tube or add the concentrated sulphuric acid in such a way as to allow it to mix quickly with the solution, for it develops great heat and may scatter the contents of the tube with explosive violence.

Apparatus and reagents required.

1 dozen large test tubes.
1 2-inch glass funnel.
1 package filter paper, Schleicher & Schüll's No. 595, 7 cm.
1 alcohol lamp.
4 inches platinum wire.
1 square inch of blue cobalt glass.
1 bottle concentrated hydrochloric acid.
1 bottle concentrated ammonia.
1 bottle concentrated sulphuric acid.
Crystals of ammonium oxalate.

Crystals of sodium phosphate.
Crystals of ferrous sulphate.
Crystals of barium chloride.
Solution of silver nitrate.
N/20 $KHSO_4$ solution.
Phenolphthalein indicator.
Methyl orange indicator.
Red and blue litmus paper.

Collection of Laboratory Samples of Alkali Soils, Crusts, and Waters.

Samples of water, crusts, etc., sent to the bureau laboratories for chemical examination, or for the purpose of checking the accuracy of the bridge, should be fully noted and described in the field note book and accompanied by a description on Form 48.

In collecting water for analysis three or four of the sample bottles protected by mailing cases should be thoroughly rinsed out and then filled. In collecting alkali crusts, only clean, firm sacks should be used, and in the case of highly concentrated sodium carbonate crusts two or three sacks, one within the other, should be used to inclose the material, because of its corrosive properties.

FORM OF A SOIL SURVEY REPORT.

A soil map of an area needs for its proper interpretation a report carrying a description of the soils, a discussion of their economic relations, and a statement of their agricultural possibilities, and this in turn requires that consideration be given to existing physical conditions such as climate, topography, and physiography, and location with respect to transportation and market facilities.

The matter should be presented in a direct style, and no more words used than are absolutely necessary to convey the meaning, being careful, however, to treat each subject so that all important phases may be brought out and clearly stated. In order to attain this, the different chapters should be revised several times if necessary, so that all important matters may be considered and all unnecessary words eliminated. A careful consideration of this matter of style in writing is enjoined upon all members of the bureau charged with the preparation of reports. The material for the report should

be collected, and the writing of the report should be done, as far as practicable, before the party leaves the area. It is desirable that the manuscripts should be legible and written upon sheets of uniform size and only on one side of the sheet. Those charged with the preparation of reports are particularly cautioned against crowding the lines. Ample space, at least half an inch, should be allowed between the lines to facilitate interlineations in correction.

The following outline of chapters is given as a guide in the arrangement of a soil survey report and should be followed as closely as circumstances will permit:

I. Description of the area.
II. Climate.
III. Agriculture.
IV. Soils.
V. Drainage, irrigation and alkali, when of significant importance to the use of the soils of the area.
VI. Summary.

These several subjects will be treated in the following manner:

Description of the area.—Give the size in square miles and acres and the location and boundaries of the area.

Describe the general topographic and physiographic features, the object being to give a picture of the surface of the area as a whole. The principal topographic and physiographic features will be mountains and plains or, at relatively higher elevations, plateaus, and valleys, with intermediate forms of dissected plains or plateaus or rolling country or hills of such moderate height as not to justify the name of mountains. It is important to indicate in a general way the character of the slopes, whether gentle or steep, and whether smooth or rough as this has an important bearing upon agricultural operations and use. It is well in describing a mountainous section to give an idea of the general steepness of the slopes and of the general direction of the ridges, and whether they are linear or curving, the character of the mountain masses and whether they contain areas adapted only to grazing or to fruit growing or other agricultural use. It is well to give the elevation of some of the more important topographic or physiographic features and the general elevation of the area.

The regional drainage is to be described with reference to the area as a whole rather than with reference to any particular soil type. It should be described in terms of the completeness of the drainage over the whole area, i. e., whether all parts of the area are reached by drainage ways or slopes to them or whether some parts of it still retain a simple constructional surface form without adequate provision for natural surface drainage. The depth of the dissection by the streams and the width of the larger valleys should be stated. Where the streams are small or are still so young that a uniform grade profile has not yet been established some idea of the fall should be given.

Describe the character, source, and distribution of the population. The density of the rural population per square mile is significant.

Name the chief towns, the principal transportation facilities and the important markets for the disposal of the products of the soil.

Climate.—Put in a very brief statement of the climatic features, using the Weather Bureau statistics furnished by the office. Any observed relations between the agriculture and climate may be brought out, especially where conditions differ in different parts of the survey or where they are unusual or particularly important from the agricultural point of view.

Agriculture.—This subject should begin with a brief history to show the length of time the soils have been under agricultural occupation, the changes that have taken place in the character of agriculture, owing to economic, social, or other causes. The object of this discussion is to show the different agricultural practices and uses to which the soils of the area have been subjected in the past.

A careful statement should then be made covering the present condition of agriculture in the area. For this purpose the Census returns of the acreage or value of the principal crops by classes will serve as a guide. The influence of the soil or of topography, physiography, local climatic conditions or market conditions should be brought out in describing the local distribution of these crops in the area. In order to fix this matter in the mind of the soil man and to convey the correct impression of existing conditions to the reader it is sometimes advisable to prepare a small sketch map of not

exceeding a township in one or more localities in the area upon which the actual distribution of the different crops or classes of crops as they exist at the time of the survey is shown. This will be found particularly advantageous in such areas as are not uniform but where from differences in soils, topography, physiography, or climatic conditions there are local segregations imposed by natural or artificial causes. The inspector or officer in charge will indicate when and where the construction of such maps is advisable.

It will be well to show in this general chapter on agriculture how much recognition is now given to the general adaptation of soils to classes of crops and to agricultural industries.

The report will then discuss the agricultural methods in use, including the adequacy of farm equipment, the methods of cultivation, the rotation of crops, the extent and character of fertilization, and other practices in use to bring out the full measure of soil productivity.

The character and cost of labor available for the handling of the soil should be stated. The size of farms and the tenure should be shown, to bring out in general the magnitude and methods of the unit control of the soil, and finally a statement should be made of the range in value and average value of farm lands.

Soils.—The description of the soil types encountered in the area should be preceded by a general chapter discussing the origin and mode of formation of the soils of the region as a whole, particularly with reference to that phase of geology that has to do with the lithological character of the material. It is important that the geological relationship of the soils should be shown, but the name of a geological formation should never be given without reference to a geological map of the area or the statement of some recognized authority. The soil man, however, is supposed to know how to identify the common rocks and may name the rocks on his own authority if he is sure or can satisfy himself about the identification, but such statements should be in general terms, such as limestone, sandstone, shale, slate, granite, diorite, gabbro, basalt, diabase, rhyolite, trachyte, gneiss, schist, and serpentine. If unable to identify the igneous rocks he should at least describe them as light or dark colored, as coarse or fine grained, as quartz-bearing or

quartz-free rock, as the case may be, with abundant hornblende or such other mineral as they may contain.[1] The field man should keep clearly in mind that the age of a rock is of no essential value in soil classification but that its lithological character is of very great value.

The relation of soils to the general physiographic features should be discussed, and formative or modifying agencies of significance pointed out. Then the classification and distribution of the soil series should be taken up, particularly with reference to the character of the material and the agencies which have been operative in its accumulation.

In taking up the detailed description of the soil types all the types within a given series should be described before any other type under a different series, regardless of its relative importance in that particular area, is taken up and each series group should be preceded with a short description of the series, giving the color of soil and subsoil, texture of the soil when it is distinctly different from that of the subsoil, the structure of the subsoil, derivation of the material, the process of its accumulation and the topography. This should be brief. This series description is to be the typical series description, not a description of the series as it occurs in the area under discussion if it varies in that area from the typical.

Next there will follow a detailed description of each soil type encountered in the area. Give first the color, texture, and depth of soil and subsoil, the character of any substratum observed, and any mineralogical or chemical feature which is apparent.[2] Follow this with a statement of the location of the soil in the area, the character of the surface and the drainage conditions. Include if necessary more detailed description of the origin and process of formation than that already given in the series description, but this will rarely be necessary.

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[1] Where unable to identify or to determine the lithological character of an important soil-forming rock, the field man may send specimens to the laboratories for identification.

[2] Where areas of other soil types, because of their small size or the complexity of arrangement, are included with any soil this fact should be stated, and where the included material is of sufficient importance some space may be given to its description.

Follow this with a discussion of the economic relation of the soil type to the agriculture of the area. State approximately how much of the soil type is actually in use at the present time for agriculture. If a considerable part of the type is not in use for such obvious physical reasons as rough topography, insufficient or excessive drainage, alkali, or other cause, discuss briefly the possibility of use through reclamation or modified use. Describe the important crops that are being grown on the type, not a mere list of crops but a carefully weighed statement based upon observation of the relative importance of the crops or industries. Tables compiled from reports of the Census showing the acreage and yields of all important crops of the county will be furnished each field party on request as an aid in the preparation of this material. Appended is a list of all crops of the United States as reported by the Census with their relative values. Care must be taken at all times to express the relative importance of crops in the soil type as a whole or on that portion of it which is in use. An important garden vegetable should not be mentioned in such a way as to indicate that it is an important commercial crop unless such be the case. The observed result of a single individual in successfully producing a crop new to the soil type may be mentioned by way of suggestion, but must not be used as a basis for a definite statement of general application. In discussing animals or anima products it will be well to state not only the different kinds of animals produced and the importance of the business, whether commercial or not, but also whether the soil is used for range cattle or feeding cattle or both, or for dairying. The type of dairying should be brought out. If potatoes are recognized as an important commercial crop the period of maturity of the crop should be given to indicate the market period served, to show whether they will be available for spring, summer, fall, or winter use. An important industry developed on a small portion of a soil type must be described as an example of local use, carefully restricting the application of the statement in the present use of the soil as a whole, otherwise such discussions may be misleading. Conservative statements should be made of the yield of the principal crops either in

average figures for the type as a whole or as yields obtained under average methods and under good farming methods. This is done to illustrate the productivity of the soil type as compared with other soils in the area and to suggest what may be expected by improving the methods. Statements concerning yields should be very carefully made and based on carefully obtained evidence only. The field man should not forget that the yields of crops depend upon many other factors besides the single one of the soil.

There are three classes of data on which field men are apt to base statements of crop yields as follows: (1) Actual figures gathered and sifted with care and discrimination. (2) Observation of the actual appearance of crops during the progress of the field work. (3) General impressions gained during the progress of the field work but rather unconsciously. In every case the field man should state the basis on which he makes a statement of crop yields.

In this chapter something should also be said of the prevailing methods of handling the soil and of the fertilizer practice. Land values, the range in price and average price, should be shown. These should be based on actual transfers, if possible. In all cases, however, the basis of any statement should be given.

Great care must be exercised in making recommendations for possible improvement in the form of agricultural practice, as it must be recognized that this depends upon other factors than soil character, and other bureaus are considering and actually handling questions of introduction of methods, crops, and industries connected with their work.

Suggestions of this kind and statements regarding adaptations of the soils to crops not now grown in an important way within the area coming from this bureau should be tentative, and when based upon observations made outside of the area, so far as possible, the basis for these suggestions should be given and the localities, where the changes suggested have been in actual operation, should be stated. Specific reference should be made to such localities and to such cases in order to show that the suggestion comes from actual observation and to enable verification of the value of the proposed change by investigation of the authority or the case cited. Further-

more, such a suggestion must not be made as of general application if it is known to be dependent upon and applicable only to local conditions of transportation, market demands, or other limiting causes, without bringing out these limiting conditions.

Irrigation, drainage, alkali.—In cases where irrigation, drainage, or alkali conditions constitute a controlling factor in the use of soils, special chapters may be prepared on such subjects, but the subjects must be briefly stated and discussed only in their specific bearing upon the character and use of the soil.

Summary.—Prepare a brief paragraphic résumé of salient points brought out in the report. This should include the use of soils, deductions made from the study of conditions and methods of handling the soil, and suggestions for improvement or changes in the agricultural methods, and in the crops grown, under the limitations above mentioned.

APPENDIX.

The value of the agricultural products of the United States.

[1910 census.]

	Value.	Per cent.
Cereals, 1	$2,665,539,714	33
Animals sold or slaughtered, 2	1,833,175,487	23
Cotton and seed, 3	824,696,287	10
Hay and forage, 4	824,004,877	1
Dairy products sold, 5	473,769,412	5
Fowls and eggs sold, 6	256,041,773	3
Other vegetables, 7	216,257,068	3
Potatoes and sweet potatoes, 8	201,853,080	2
Forest products of farms	195,306,283	2
Orchard fruits, 9	140,867,347	2
Tobacco	104,302,856	1
Other grains and seeds, 10	97,536,085	1
Wool	65,472,328	1
Sugar crops, 11	61,648,942	1
Flowers and plants	34,872,864	[1]
Small fruits, 12	29,974,481	[1]
Tropical and semitropical fruits, 13	24,706,753	[1]
Grapes	22,027,961	[1]
Nursery products	21,050,822	[1]
Other minor crops, 14	18,068,658	[1]
Nuts, 15	4,447,674	[1]
	$8,115,620,752	

NOTES.

1. Cereals—values:

	Per cent.
Corn	54
Wheat	25
Oats	15
Barley	3
Rye	1
Rough rice	1
Kafir corn and milo maize	[1]
Buckwheat	[1]
Emmer and spelt	[1]

[1] Less than one-half of 1 per cent.

2. Animals sold or slaughtered—values:

	Per cent.
Cattle and calves	40
Swine	37
Horses	11
Mules	5
Sheep	4

3. Cotton and seed—values:

Cotton	85
Seed	15

4. Hay and forage—tons:

Timothy and clover	26
Wild, salt or prairie grass	19
Timothy alone	18
Alfalfa	12
Coarse forage	10
Grains cut green	5
Other tame or cultivated grasses	5
Clover alone	2
Millet or Hungarian grass	1
Root forage	(1)

5. Dairy products—sold:

Milk and cream	61
Butter and butter fat	27
Cheese	2

6. Fowls and eggs—sold:

Eggs	70
Fowls	30

7. Other vegetables:

Relative acreage—	Per cent.	Relative values—	Per cent.
Tomatoes	20	Tomatoes	20
Sweet corn	17	Cabbage	16
Watermelons	13	Onions	10
Cabbage	13	Sweet corn	9
Green peas	7	Watermelons	7
Green beans	5	Celery	6
Cantaloupes	5	Cantaloupes	5
Onions	5	Green beans	5
Cucumbers	3	Green peas	4
Asparagus	3	Cucumbers	4
Turnips	2	Asparagus	4
Celery	2	Lettuce	3
Pop corn	1	Turnips	2
Spinach	1	Spinach	1
Lettuce	1	Cauliflower	1
Carrots	(1)	Carrots	1

[1] Less than one-half of 1 per cent.

7. Other vegetables—Continued.

Relative acreage—Con.	Per cent.
Green peppers	[1]
Cauliflower	[1]
Beets	[1]
Squash	[1]
Rhubarb	[1]
Radishes	[1]
Kale	[1]
Horse-radish	[1]
Pumpkins	[1]
Eggplant	[1]
Parsnips	[1]
Rutabagas	[1]
Sprouts	[1]
Okra	[1]
Parsley	[1]
Green onions	[1]

Relative values—Con.	Per cent.
Green peppers	1
Beets	1
Rhubarb	1
Pop corn	1
Radishes	[1]
Horse-radish	[1]
Squash	[1]
Eggplant	[1]
Kale	[1]
Parsnips	[1]
Sprouts	[1]
Green onions	[1]
Rutabagas	[1]
Pumpkins	[1]
Parsley	[1]
Okra	[1]

	Per cent.
8. Potatoes and sweet potatoes—values:	
Potatoes	82
Sweet potatoes	18
9. Orchard fruits—values:	
Apples	58
Peaches	20
Plums and prunes	8
Pears	5
Cherries	5
Apricots	2
10. Other grains and seeds—values:	
Flaxseed	29
Dry beans	22
Peanuts	19
Grass seed	17
Dry peas	11
Flower and vegetable seeds	1
11. Sugar crops—values:	
Sugar cane	43
Sugar beets	32
Sorghum cane	16
Maple sugar and sirup	9
12. Small fruits—values:	
Strawberries	60
Raspberries	17
Blackberries	13
Cranberries	6

[1] Less than one-half of 1 per cent.

	Per cent.
13. Tropical and semitropical fruits—values:	
Oranges	71
Lemons	12
Grapefruit	8
Figs	3
Pineapples	3
Olives	2
14. Other minor crops—values:	
Hops	43
Broom corn	28
Not specified	26
Hemp	3
15. Nuts—values:	
English walnuts	52
Pecans	22
Almonds	16
All others	10